ECEMBER, 1944 ONE SHILLING & SIXPENC

Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIAL

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DETROIT

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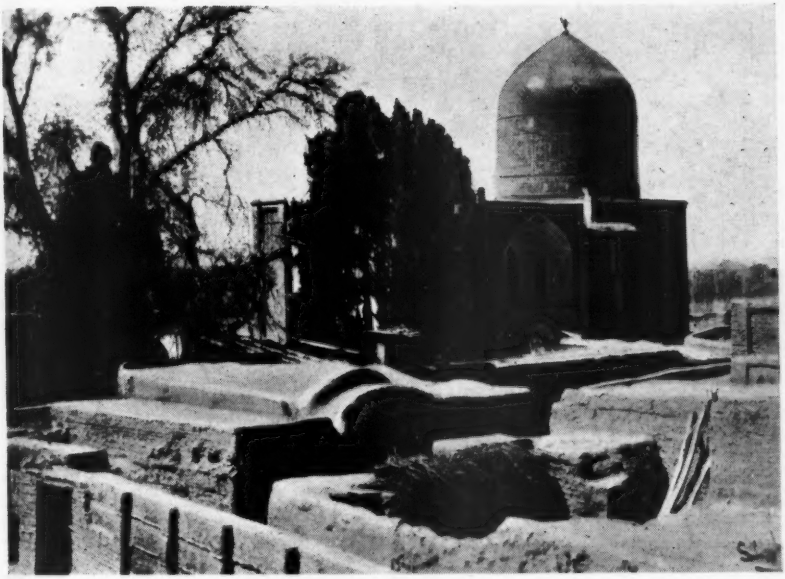

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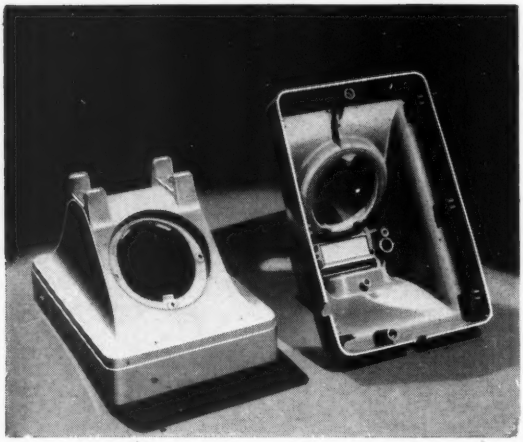

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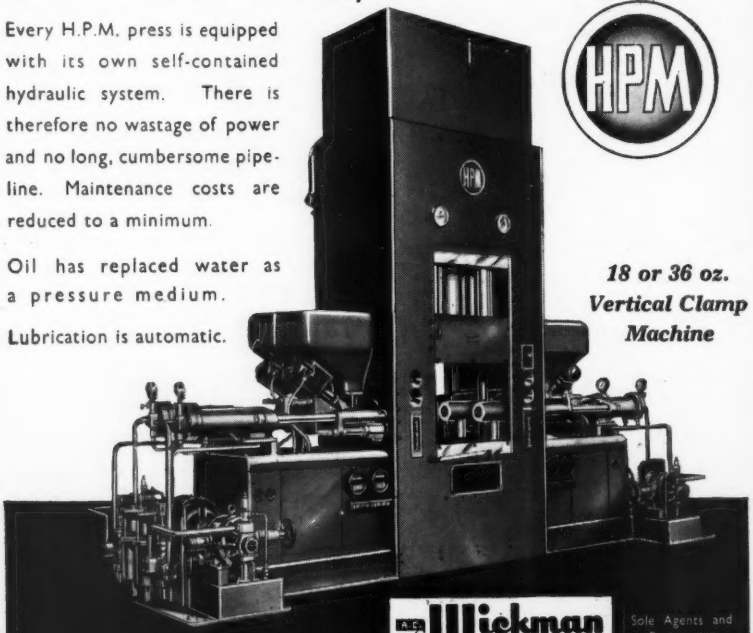

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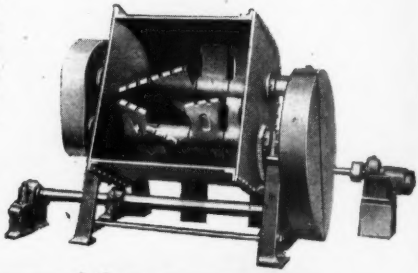

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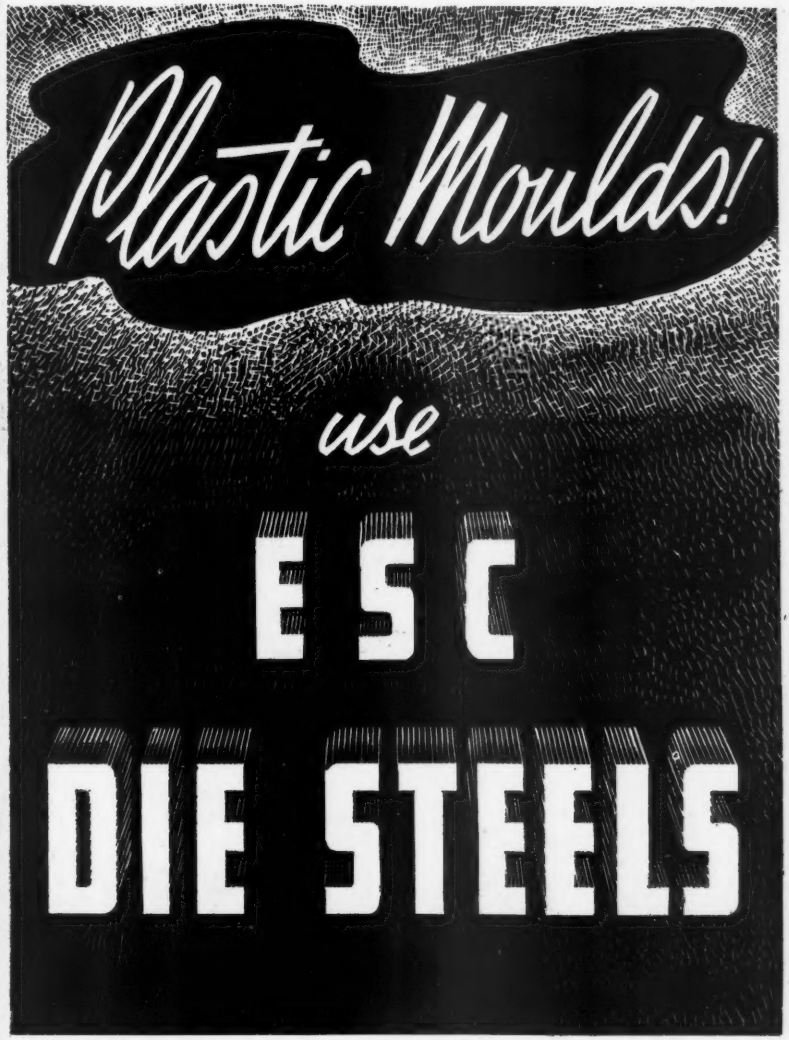

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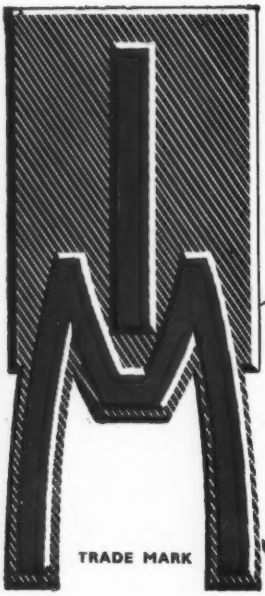

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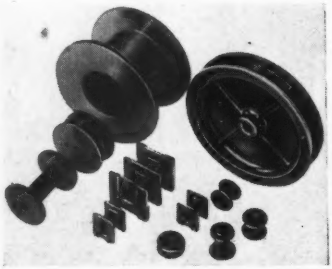

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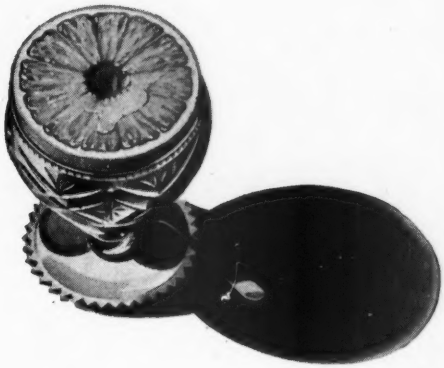

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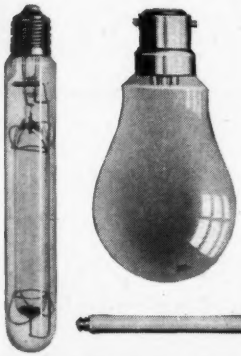

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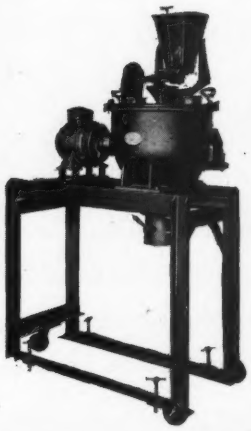

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SOME OF THE ADVANTAGES OF FEROBESTOS

1. Does not swell in water or aqueous solution.
2. Withstands high temperatures.
3. Is economical and resistant to all but the strongest acids and alkalis.
4. Can be lubricated by oil, water or aqueous solution.

FEROBESTOS

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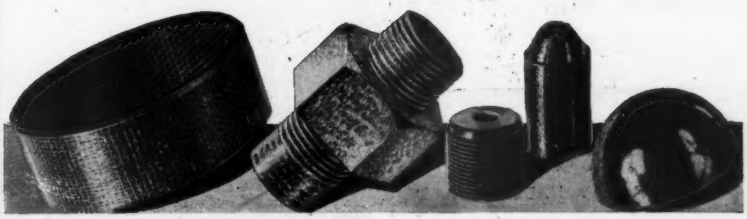

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ADVICE upon which you can rely as to the type of Plastic best suited to the specification of your job.

CO-OPERATION in the initial designing in order to make the job a sound moulding proposition.

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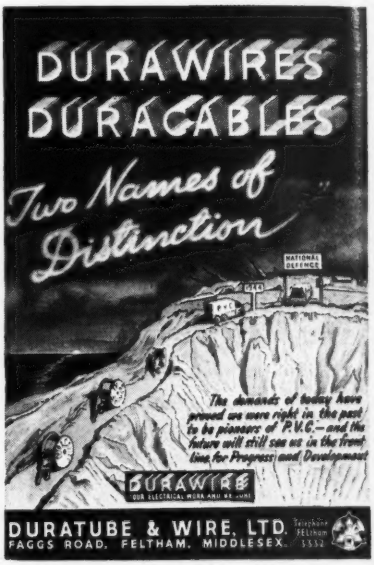
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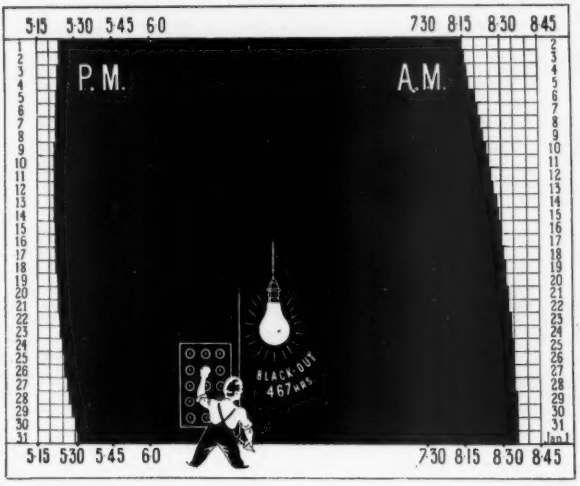

★*Times shown are those for the London area.*

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December! — the year's darkest month — *this* year happily relieved by easier black-out restrictions. All the same, you need to know black-out times in case of alerts. In factories, whether the black-out is removable or permanent, there's always the need for good lighting if output is to be kept up to support the crowning offensive. So light up with Osram and keep up the fight until victory ends the black-out for ever.

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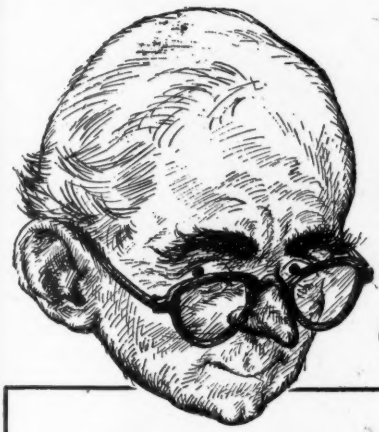

The back-room boys have a word for it..

This is a long story to be told in a short space. Briefly then . . . in 1911 we started printing and engraving on celluloid, and as new plastics came along we worked on them too. People found that we were good, so good, in fact, that we were continually asked to fabricate the articles we printed. We are nothing if not enterprising, so we got started and today you find us able to print, engrave, manipulate or fabricate every kind of plastic sheet, rod or tube. Not a mean achievement. Then with the war, the back-room boys got hold of us. Ever since we have been hard at it devising, making and engraving the most brainy contrivances . . . the sort of things about which "the story may not yet be told"! The boys are keeping us hard at it, but even so we would be interested to hear from you if this little story suggests a way in which we might help with your post-war plans.

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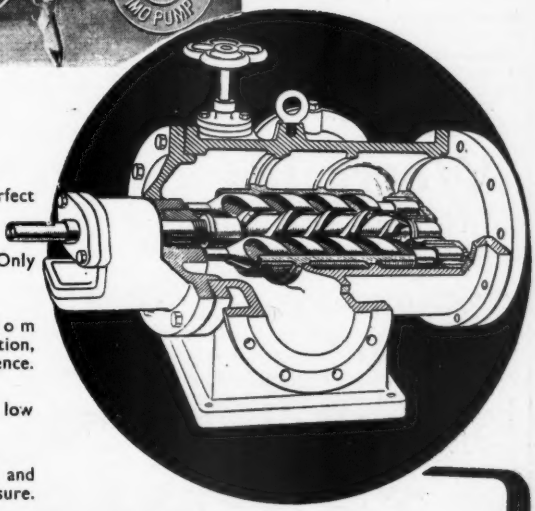

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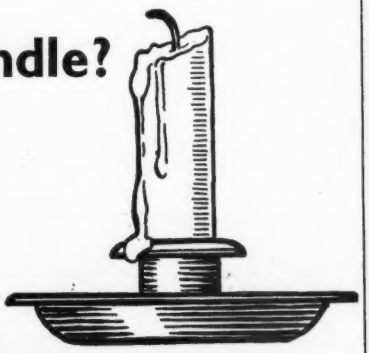

THE MASSON ROTARY CUTTER

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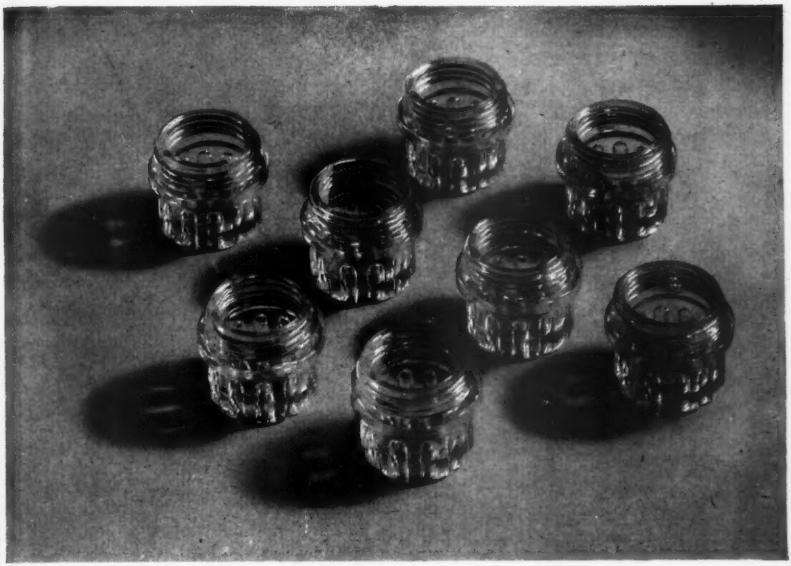

OUR LIPS ARE SEALED regarding some of the spectacular uses to which plastic materials have been put in the equipment of our fighting forces. But we can tell you that the advances which have been made in the composition and manipulation of plastics under the stress of wartime necessity are available for the radio and electrical industries and for all manufacturers who require materials that are light, cheap, of tested reliability and good design.

CASCELLOID are manipulators of every kind of plastic material and can give you information and suggestions which will help solve some of your present and post-war problems, particularly where they concern thermoplastic mouldings. Consult with us and learn more of the results which can be achieved in this field.

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De La Rue Plastics LTD.
De La Rue Insulation LTD.
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REGENT ST.
LONDON. W.1.

Vol. VIII. No. 91 DECEMBER, 1944

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

Editor - - M. D. CURWEN, B.Sc., A.R.I.C.
Offices - Bowling Green Lane, London, E.C.1

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NOTICES

All instructions, matter and passed proofs for all kinds of advertisements must reach the Head Office of "PLASTICS" by the 24th of each month to ensure insertion in the following month's issue.

TERMS—Monthly accounts, strictly net; due when rendered.

"PLASTICS" is published in London, England, at the beginning of each month.

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Bowling Green Lane, London, E.C.1.
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Cables - - - - - "*Pressimus, London.*"
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SAVE PAPER

More than ever is paper waste required for our war industries. Waste paper makes munitions in a hundred forms—from shell cases to aeroplane parts.

The fact that goods made of raw materials in short supply because of war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

EDITORIALS

Tropic Packing

IF you are a manufacturer—of plastics, of machinery, of anything, you must visit the Anglo-American Services Exhibition on Preservation and Packaging at Central Ordnance Depot, Feltham, Middlesex. It will continue for some months yet.

During the early days of the campaign in Burma and New Guinea, a scientific committee in Australia wrote a report on its findings, on the conditions of fighting, on the conditions under which arms and equipment were used, and what happened to them often before they ever reached the firing line. It was a story shocking to those who know nothing of what vast distances, tropical climate, and jungle pests really mean. The story is told in another way, and how we now can combat these allies of Japan, at this Anglo-American Services Exhibition.

Here we see how crates of stores can be damaged in transit, how contents can deteriorate and arrive quite useless. Aluminium and steel parts corrode in these climates overnight, foodstuffs become damp and uneatable, leather is destroyed, and plastic parts can grow mould. Mirrors spoil and rubber rots. What is the use of all the labour at home if the fruits of it never arrive or are rendered useless before they get to the fighting man?

The place to defeat the distances, climate, terrain and jungle pests is in the factories at home, and no man can rest easy until the fight is won.

The answer to the problem is Preservation of Stores, Identification of Stores and Packaging of Stores, and the Exhibition explains with amazing detail how these are carried out, for all the myriads of units that must travel over the seas must be protected, properly identified, and properly packed. We have learnt most of the lessons and they will stand us in good stead when war ends and we begin to transport our peace-time products. We also here learn the lesson of what plastics can do in the process of preservation. It is a great deal.

Polystyrene Problem

THERE is one thing that all moulders are agreed upon—in their esteem for polystyrene as a moulding material. Users, too, are loud in their praises of this outstanding resin, of its permanent beauty, and its technically important optical properties, of its dielectric worth.

It is easy to predict a great future for polystyrene. It doesn't need even a minor prophet to tell us that, and we need not concern ourselves on that score. What does concern us are two aspects of the problem—availability and price.

There is no published figure of production for polystyrene in this country, but if we give it as 300 tons per annum it is probably not more than 50 per cent. too high. This quantity is admittedly small, but it is apparently sufficient, although we import some from the United States for our war needs. It must not be forgotten that by far the greater number of injection mouldings are very small, and that from 300 tons of polystyrene we could manufacture 40,000,000 objects the size of an accumulator cap.

We can presume that production in the U.S.A. of polystyrene *for moulding purposes* is not fantastically greater, although probably about 1,000 tons.

We do reach fantastic figures when we examine the American "polystyrene" production for making GR-S, the synthetic rubber copolymer of butadiene and styrene. Without straining the chemical analogy too much, we may say, for our present purpose, that for this manufacture the U.S.A. are producing 150,000 tons of polystyrene! We need not excite

ourselves greatly over this figure, for it is far higher than anything the world could use for a long time to come. Many of the styrene plants may be abolished, but the capacity of the remainder will still be large enough to supply the whole world. Shall we in this country import additional polystyrene for our own growing consumption and for the export trade we must maintain and increase in order to live? How will our own styrene and polystyrene plants grow? And what will be the price of polystyrene in post-war days?

Let us say at once that we have never been protagonists in any "low-price-plastics-for-ever" campaign. We have always maintained this to be of secondary importance compared with design, and that the difference between 5s. and 4s. a pound polystyrene would make little difference in a beauty compact which sold at 5s. and contained rather less than one pennyworth of the resin. But now it is no longer a difference of a shilling. It is much more—so much more as to make us change our opinions.

As an amusing commentary on this question of raw material cost, we would remind our readers that in June, 1941, we began an article with the following:—"In the month of February we had the pleasure of listening to one of the most fascinating and informative lectures we have yet heard in the rooms of the Chemical Society in Burlington House. It was on the subject of polystyrene, or, rather, the polymerization of styrene. Unfortunately, at the end of the lecture somebody in the audience asked the author of the paper a question about the price of polystyrene, inferring that it is very high. The lecturer, instead of sticking to the science of chemistry, of which he is an undoubted master, and replying that he never concerned himself about price, said that polystyrene, with its remarkable properties, should or could be used only for special jobs where high cost warranted its use."

It would be interesting to get the lecturer's views as to what these special jobs are and whether he has changed his views during the past three years.

We should also like to ask him whether he had heard of the rumour that polystyrene can be (this verb is accompanied by the more positive "will be") manufactured at 10 cents a pound! It will be remembered that a semi-official American statement gave it that synthetic rubber would be produced at about 15 cents a pound, so that the 10 cent price is not widely out.

At this figure we may ask ourselves, What will happen to our own production?

Toyland

IF we are permitted to dream at all about post-war projects, it is both pleasant and instructive to consider toys. Not the things, let us protest, that are now being offered to a toy-starved child world; not the horrors that are fabricated in some back-street of filched plywood or from discarded bully-beef tins and sold to frantic parents for the price of an honest man's labour of a week. Not these, but the pretty or clever or funny or instructive and colourful toy that was known to every child over five years of age. The younger have never had such luck.

Production has long ceased, but what a fruitful field there is for this country in the coming years. Toy manufacture had been well established in this country by a few concerns which had already shown their ingenuity and the high quality of their products. But vast quantities were still being imported into this country from Germany and Japan and it is to be hoped that the industry will seize its opportunity and make its position unassailable.

Our eyes have been opened as to the possibilities of plastics by a meeting with Mr. Hilary Page, a toy maker and a student of child psychology, who has for some years adopted plastics for his special line of educational toys. Some of his products, moulded by several well-known concerns in our industry from amino-resins, are brilliantly designed and are the result of careful thought and

knowledge of the purpose in view. We have prevailed on Mr. Page to give us his opinions on this subject in a forthcoming issue of this journal and so help resin manufacturers and moulders to understand the problems involved.

LETTER TO THE EDITOR

Resin Impregnated Pulp

Sir,—Reading your comment on the " ill-timed criticism " of Mr. Martin's paper on " Resin Impregnated Pulp," I gained the impression that you do not think Members of the Institute of the Plastics Industry can have much knowledge of a particular process because nothing has so far appeared on the subject in your journal. In the present instance, at least, I may attempt to correct your opinion by reminding you that the Institute has for many years past printed its own lectures for the purpose of a permanent record and a useful work of reference. I would particularly draw your attention to the 1933 issue of the Institute's " Transactions " in which, on page 23 et seq., a lecture on " Laminated Materials " is recorded. From this you will see that the method of impregnating paper pulp as the fundamental operation in the production of aniline-formaldehyde laminated boards is referred to in detail and I, too, " dare swear " that those veterans of the Institute present at that lecture 11 years ago will remember some of the many lantern slides I showed to illustrate the plant involved, including beaters. The audiences attending the lectures of the Institute are much larger now than 10 years ago, but I feel that those following the Institute's educational activities with real interest would prefer to be reminded of information existing in their own journal rather than to look up references in a chemical book such as Mr. Martin's paper mentions.. I cannot conceive what has provoked your statement that the Micanite and Insulators Co., Ltd., has not considered it feasible to publish the method of manufacture of " Panilax "—the aniline-formaldehyde pulp pre-impregnated material—since a special pamphlet, first printed in 1935, has been freely distributed to anyone interested in the material. Mr. Philippe's question after the lecture as to " why they did not get on with the job " may best be answered by stating here that at least a couple of hundred tons of " Panilax " have assisted the war effort in the production of essential materials.

With my compliments I enclose a copy of the latest issue of the " Panilax " pamphlet, and if you would like additional information for publication in your journal I shall be glad to respond to your request.

I quite agree with you that Mr. Martin's lecture was of great interest to the audience, including myself, but I cannot help feeling that Mr. Martin's absence reduced its reading to little more than a plastics catalogue reference, which it is more pleasant to read at the fireside, and hardly worth a journey under present black-out and other difficult conditions.

Since writing the above I have obtained the latest issue of the Institute's " Transactions," which contains Mr. Martin's original paper read before the Midlands Section. It is interesting to read the appended discussion when replies were made by the author to questions unfortunately unanswerable during our London meeting.

I am sure you join me in wishing Mr. Martin a pleasant return home and in spite of, or perhaps because of, my apparent critical attitude I shall not fail to contact him for the purpose of exchanging views which may well lead to improvements of processes which seem to have so much in common and both of which are likely to contribute to the so-much-desired export business we hope for in the post-war period.

Walthamstow, E.17. G. E. HAEFELY.

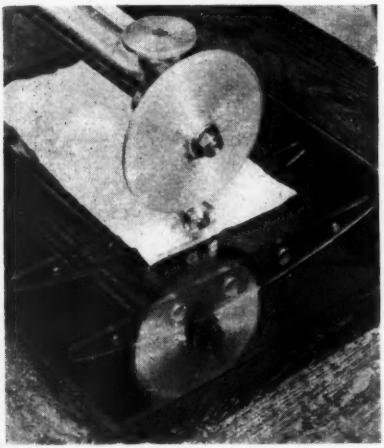
[EDITOR'S NOTE: We think that most members of the Institute cannot have much knowledge of the Panilax process for the very reasons Dr. Haefely gives. The information was published in the " Transactions " in 1933—a very long time ago—when the number of members was small. So far as we know, no wider publicity has been made since. The Institute has grown and we do not believe all members have read what happened 11 years ago. Mr. Philippe's remarks seem to bear out our contention and he has long been an enthusiastic member of the industry.

The suggestion that our criticism is due to the fact that nothing of the Panilax process was published in " Plastics " is neither tactful nor true. The journal was not in existence in 1933, and our efforts to give " Panilax " adequate editorial publicity during the past few years have not met with success. Such publicity may not be the lifeblood of industry, but it is certainly a good tonic for the blood.]

Radio-frequency Welding of P.V.C. Film

A Description of the Type of Welding carried out by Herts Pharmaceuticals, Ltd., and the Design of the Apparatus Produced by that Company in Collaboration with Murphy Radio, Ltd.

By S. C. Mitchell, B.Sc., F.R.I.C.
(Herts Pharmaceuticals, Ltd.)



Close-up of the working head of the apparatus described in this article. The two wheels and their respective driving wheels are shown. Pressure between the wheels can be varied by turning the knurled screw at the top of the arm.

A NUMBER of papers has appeared within the past year dealing with the subject of heating and welding thermoplastic materials by means of H.F. currents. Sufficient has been published to indicate the wide range of application which this technique is likely to have when equipment becomes more readily available.

The author has had occasion to carry out some development work on the application of this method of welding to certain types of films calendered from polyvinyl chloride, and it is hoped that the experience gained will be of value to those working on other problems to which these methods may be employed.

The radio-frequency sealing equipment described in this article was produced as a result of collaboration by chemists of the staff of Herts Pharmaceuticals, Ltd., and engineers of Murphy Radio, Ltd. Whilst other manufacturers' problems may differ in detail from those described, and may require specialized technique, it is thought that the principles considered here will be of great value to those who may be contemplating the introduction of R.F. heating methods.

Type of Material Used

The use of polyvinyl chloride film in this country is, of course, a development which has taken place almost entirely since the beginning of the war, and the author's interest in it arose from its possibilities for the manufacture of various sealing and packaging devices, for which it was essential to have a material which would have a high resistance to moisture vapour transmission, inertness to the common organic solvents—particularly petrol and other aliphatic hydrocarbons—and stability under exposure to extreme weather conditions such as are met with under present-day service.

At the beginning of the war the most promising film for such applications was "Pliofilm" (rubber hydrochloride), which fulfilled the above requirements, was available in very thin sheets (0.001 in.), and had a tensile strength which was unique among such films.

Adjusting spring loading on the electrodes. The cover of the oscillator has been removed for a service inspection.

Unfortunately, war conditions interfered very seriously with the supply of "Pliofilm." First of all, the shipping position deteriorated rapidly. Secondly, the United States Government had very large home requirements; and finally, with the loss of Malaya, the primary raw material, rubber, became so scarce that production of "Pliofilm" was severely curtailed as an obvious consequence.

Several samples of polyvinyl chloride/acetate co-polymer were examined, but work on these was not pursued mainly because of the very unsatisfactory supply position.

An attempt was, therefore, made to obtain a film by calendering a highly plasticized P.V.C. compound. Considerable difficulty was experienced in obtaining a film sufficiently thin to have the desired pliability and which was at the same time of uniform thickness and free from holes and blemishes produced by calendering. These difficulties were finally overcome by co-operation on the part of the firms concerned, and P.V.C. film is now quite a standard article of commerce in continuous rolls 36 ins. wide and thickness down to 0.005 in.

The original purpose for which the film was required did not call for any seams or welds, but the availability of this very useful and versatile material rapidly led to a demand for articles where some means of joining it were essential.

Several cements have been marketed for use with P.V.C., but their main field of application appears to be in the cable industry, where the conditions of use are quite different from those with which we were concerned. Some work was done on compounding a suitable cement, but we were led to the conclusion that the various

Close-up of operator at work.

chemical properties which make P.V.C. film such a useful material precluded the use of cements in the fabrication from it of packaging and sealing devices.

We, therefore, experimented with heat sealing by the usual methods of heated elements. This, again, was unsatisfactory, because P.V.C. film is rather thicker than the normal films to which heat sealing is applied. This meant that the heated elements had to transmit their heat through an appreciable thickness of material, causing over-heating of the surface before the centre parts where the weld was to be formed became plastic.

About this time we saw references in various American journals to the possibility of applying alternating current at radio frequency to the heating of materials which were reasonably good insulators but had a sufficiently high dielectric loss factor.

Preliminary Investigations

Some preliminary experimental work was, therefore, carried out in the laboratories of Murphy Radio, Ltd., with an improvised pair of wheels coupled up to a laboratory oscillator. It was readily demonstrated that P.V.C. film lent itself in a most admirable manner to heat sealing by this method. The fundamental distinction between R.F. sealing and the methods with which we had previously experimented is that when R.F. is used the heat is generated in the material itself, and not applied by conduction from an external source. Even on the rather crude laboratory set-up, welds were obtained which were stronger than the tensile strength of the material itself.

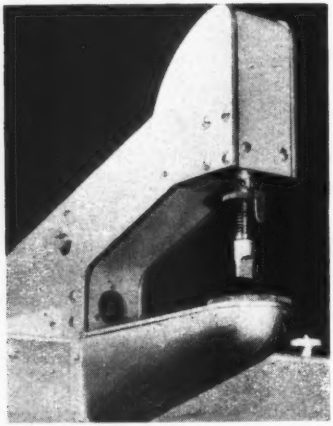
We were at this time trying to produce a design for a service requirement in P.V.C. which had been met previously by rubber latex handled according to the dipping methods which are classic for that material. To fabricate P.V.C. in film form to meet this requirement it was essential to have available a method of welding, and R.F. seemed the answer to this problem.

The data which had been published on the sealing of thermoplastic materials by R.F. indicated that the band of frequencies found most suitable for the various purposes in which other workers had been interested lay between 10 and 50 megacycles. For our particular purpose the initial laboratory work showed that better results were obtained by using frequencies above 60 and up to 100 megacycles. The requirements of the job which it was intended to try out on the machine led us to decide against the traditional hollow casting for the head of the machine —the conventional "sewing-machine" head—and to use instead an aluminium arm to carry the upper electrode. The general operation of this type of machine has been well described elsewhere, and this particular model is well illustrated by the accompanying photographs. It consists essentially of two electrodes in the form of wheels, both positively driven by a friction drive, the pressure between them being adjustable by means of a spring loading, which is controlled by a screw. The material to be sealed is thus driven forward by the wheels of the appliance, and the current is controlled by a foot switch. These machines were entirely experimental, and in the light of the information gained in their use an improved model was designed. It is hoped to give details and photographs of this in a later communication, but it may be said here that the changes found necessary were purely in the mechanical details of applying the drive to the sealing wheels and providing more flexible adjustments.

The R.F. generator illustrated in the photographs and built by Murphy Radio, Ltd., was found to behave very well. The problem of providing a unit which would give these high frequencies at the required power output, be capable of operation by unskilled labour, and for which replacements could be provided without difficulty, having regard to the present short supply of the more specialized forms of radio equipment, has been solved very successfully, and these generators have been in continuous operation for some months with a minimum of servicing.

Right at the beginning of the development work, Murphy Radio engineers

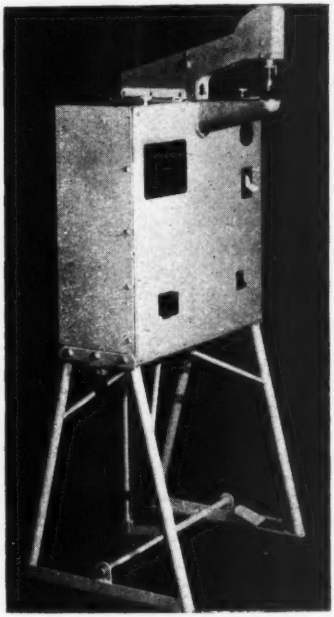
decided that a complicated system of tuning and coupling controls would be intolerable in an equipment designed for industrial use by unskilled operators. They accordingly arranged their equipment so that the only control is a hand wheel controlling the power output.



(Above) View of upper electrode of spot welder, showing spring loading with adjusting nut and interchangeable "bit." (Right) Spot welder with working table removed.

It was found a great help to have a milliammeter in the electrode circuit, and to arrange for the current flowing to be controlled by a Variac transformer, which is mounted on the front panel. This permits recording of the different current values used on various jobs, and facilitates immediate setting of the machine in changing from one material to another or in varying the thickness of material being handled. This amounts in effect to variation of the voltage gradient between the sealing wheels. A range of 70 to 150 mA was found to be very convenient according to the thickness and type of material being handled.

It is, of course, essential that the electrical resistance of the film to be sealed shall be such as to prevent breakdown of the film by voltages of the order likely to be encountered across the electrodes. It has to be borne in mind that although the electrical characteristics of the material may be constant, thickness may vary very considerably, taking into account the fact that it may be necessary to pass several thicknesses of material through the machine or a single thickness. In practice it was found that if the machine is first set to a convenient current in the electrode circuit by an experienced operator it will then run without trouble on the particular job for which it has been set. A little experience is also required by the operatives to prevent drag of the material, which would result in its being



exposed to the electrostatic field for a longer time, with consequent deformation due to the material becoming too plastic.

The general technique of sealing is very similar to the operation of a sewing machine, and no difficulty was experienced in training girl labour to operate the machines quite efficiently in a short time. On the experimental machines the

actual rate of passage between the electrodes of the material being welded was slower than is customary with an ordinary sewing machine, being about 5 ft. per minute; but the experience gained suggests that the speed which can be obtained is only dependent on the capacity of the generator to supply the current at the required rate, and, given this, the operative could manipulate the material in the same way as is done with sewing machines.

It may be helpful to give a few notes on the general seaming technique. For the fabrication of the small components with which the machines have hitherto been used, it has been found convenient to use wheels having a face $\frac{1}{8}$ in. wide, since this gives a fair amount of latitude in swinging the material being welded through sharp curves. This is required when corners or shoulders are being negotiated.

For the most part the machines have been operated by girls with no previous training in this sort of work, and facility was very rapidly acquired.

In general, a single seam is sufficiently strong for most purposes, and the usual method is to cut the material to the required shape, apply the seam with the object turned inside out and, when finished, to reverse it. It was found that this improved the appearance of the material, obviated the necessity for trimming edges, and eased the stresses on the seam. In some cases where stresses were applied at peculiar angles it was found advantageous to use double seaming, but, in general, since the seam obtained has a strength equal to the tensile strength of the original film, this offers no advantage.

One of the applications upon which the author worked was the sealing of short strips of P.V.C. film on to larger sheets. This is a general problem, and will arise wherever it is required to fasten loops, lugs, etc. The continuous-type sealing machine was found to be unsatisfactory for this purpose, and a spot welding sealing machine has, therefore, been devised.

This consists in principle of one electrode mounted horizontally in a bed of insulating material (polystyrene), and immediately above this in the working head of the machine is a removable and interchangeable electrode, which can be depressed downwards on to the bed by a system of levers operated by a foot control. The pressure applied is adjusted by means of a spring controlled by a milled nut, and it is quite independent of the pressure applied to the foot treadle. As the foot treadle is depressed it does three things: first, it brings down the electrode into contact with the material, then it applies the pressure from the spring loading at whatever value this has been set for, and finally it switches on the current. This means that the welding of the joints does not take place until the material is already in position, held between the electrodes at the right pressure. Since the time of application of the current is critical and quite often is only a fraction of a second, it is of great advantage to the operator in judging this time correctly. As an additional assistance a pilot light is mounted in the front of the head of the machine, which lights up as the current comes on. With a little experience operators learn to estimate the time required from a mere wink of the light up to one or two seconds, as is required.

The design of the machine is seen in the accompanying photographs. It will be noted that the power pack and oscillator are all contained in the rectangular case, which forms the body of the machine, and the whole thing is sufficiently light for a girl operative to move it from one place to another quite easily and plug into a power socket.

Acknowledgments

The author wishes to record the excellent co-operation of the staff of Murphy Radio, particularly Dr. Connelly and Messrs. Newton and McKay. He also thanks Messrs. Plastic Research and Development, Ltd., in whose laboratories the production experience has been gained for much valuable help, and, finally, Messrs. Herts Pharmaceuticals, Ltd., for permission to publish this article.

Measurement of the Thermal Conductivity of Plastics*

IN the following account a few of the methods for measuring the thermal conductivity of plastics are described; they are also generally applicable to other bad conductors, the conductivity of which lies between 0.1 and 0.8 kilo. cal./hr.-metre °C.[1]. The methods described are classed as either static or dynamic, according to the technique employed.

1. Static Methods

The following equation is used as a basis for calculating thermal conductivity:—

$$Q = \lambda \cdot \frac{A}{d} \cdot \Delta\theta$$

in which

- Q = quantity of heat transmitted in unit time through the specimen.
- λ = thermal conductivity.
- A = area of the specimen.
- d = thickness of the specimen.
- $\Delta\theta$ = temperature difference across the specimen.

The measurement of the dimensions of the specimen and the temperature difference across the specimen afford no difficulty, but measuring the quantity of heat transferred is not so easy. Consequently, this latter determines the construction of apparatus and the difference between the various experimental techniques.

(a) Method of Batsch and Meissner[2]

Fig. 1 shows a section through the apparatus used. The specimen is a disc, about 80 mm. in diameter; its top surface is heated electrically and its bottom surface is kept cool by circulated water. The electrically heated plate is kept in close contact with the specimen by means of an electro-magnet placed beneath; this eliminates conduction errors inherent in clamping devices. Convection losses can be eliminated by maintaining the whole apparatus in vacuo (i.e., 2×10^{-2} mm. mercury). The quantity of radiated heat is determined, and by subtracting this from the total heat supplied electrically, the amount of heat passing through the specimen is known. The hotplate is coated with polished aluminium foil to keep radiation to a minimum. The temperature drop across the specimen is measured with a thermocouple (not shown in the diagram). The accuracy of the method is about 5 per cent.

(b) Method of Erk, Keller and Poltz[3]

Fig. 2 shows a section of the apparatus. The specimen (c) is connected in series with a glass plate (e), the thermal conductivity of which is accurately known. As the amounts of heat transferred through the specimen and plate are equal, the inverse of the temperature fall in unit thickness of the specimen is a

* Translated from a paper by Fr. Gottwald published in Archiv für Technisches Messen, May, 1943 (V. 9213-3).

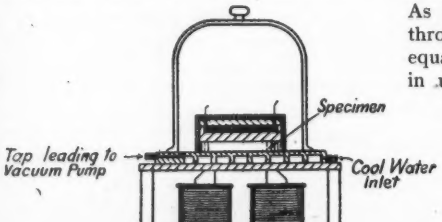


Fig. 1.—Batsch and Meissner's apparatus for measurement of thermal conductivity.

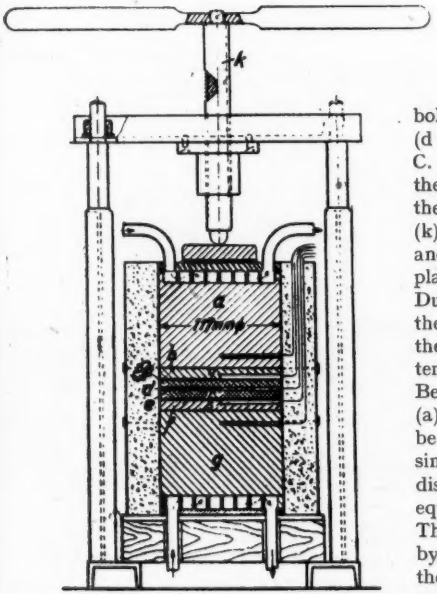


Fig. 2.—Erk, Keller and Poltz's apparatus.

measure of the thermal conductivity. A temperature differential is maintained between the bottom of the glass plate and the top of the specimen by means of a flow of thermostatically heated water circulating through the aluminium cylinders (a) and (g). The temperatures on the surfaces of the specimen and glass plate are measured by the thermocouples (q, r, s), which are imbedded for convenience of manipulation in the copper plates (b, d, f). The plates are kept in compression by means of a screw (k).

The method is accurate to about 1 per cent. The expense of the apparatus is considerable as it includes two sensitive thermostats.

(c) **Method of We. Koch**[4]

This method was devised as a simplification of the method of Erk, Keller and Poltz. A section of the apparatus is shown in Fig. 3.

In the usual arrangement, a plate of bakelized paper (a) is secured to two aluminium plates (b and c) by screw bolts. Heating is produced electrically (d and g), and a temperature of 48 degrees C. is maintained by means of a contact thermometer (e). On top of plate (c) is the specimen (i) and above this a plate (k), conveniently made of aluminium, and kept cool by a flow of water. The plates are held together under pressure. Due to the lack of close control, the ultra-thermostat may be omitted, though, at the same time, the advantage of different temperatures in the measurement is lost. Besides being conducted through plate (a), an appreciable amount of heat will be conducted through the screw bolts since they are of metal. The irregular distribution of heat thus produced is equalized by the aluminium plate (c). The influence of the bolts is allowed for by calibration. The temperature drop in the standard plate (a) is measured by several thermocouples, one behind the other. Since the temperature of plate (b) is kept constant at 48 degrees C. and the temperature of the cool plate is measured with an inserted mercury thermometer, the temperature drop through the plastic plate (i) is known, and, hence, the thermal conductivity can be calculated. An additional control with plates of known thermal conductivity is necessary from time to time. The accuracy of the measurement is about 2 per cent.

In order to keep heat transmission negligibly small in all three methods, the specimen must be ground smoothly. It is also important to put oil between the plates. The disadvantage of all the above methods is that measurements can only be made after the attainment of a stationary state. The time for a measurement will depend on the nature and thickness of the plate and amounts to between a half and two hours.

2. **Dynamic Methods**

In these methods the rate of conduction of temperature (a) is measured and not

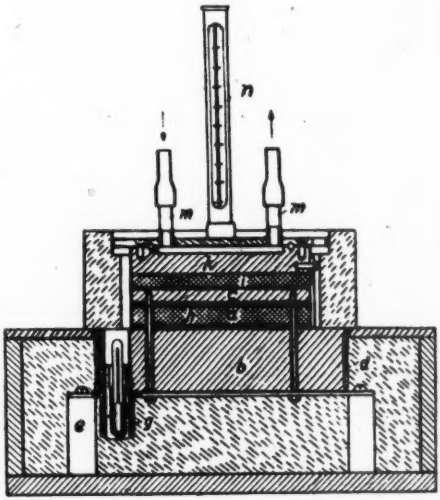


Fig. 3.—Koch's static method for thermal conductivity estimation.

the rate of conduction of heat λ. The equation connecting these values is—

λ = a.y.c., where
c = specific heat.
y = weight of material.

Dynamic methods cannot be made generally applicable because the calculation involved is most intricate. Since the whole procedure cannot be easily surveyed, the correction of disturbed flow is also difficult. These difficulties may be overcome by dispensing with an absolute measurement, and carrying out instead simultaneous calibrations on material of established conductivity.

The dynamic heat flow is represented by the differential equation of the thermal conductivity, which, in the sample form, is as follows:—

$$\frac{\delta\theta}{\delta t} = a\frac{\delta 2\theta}{\delta x^2}$$

In this—

θ = temperature.
t = time.
x = distance co-ordinate in the direction of heat flow.
a = temperature conductivity.

(a) Pyk and Stalhane's Transfer Plate

A dynamic transfer method was devised by Pyk and Stalhane,[5] and further improved and its accuracy determined by Steger.[6] It is also useful for plastics.[7] Fig. 4 shows the apparatus. It consists usually of a double-walled tank. The inner container is full of mercury maintained at a constant temperature. Heating provided by steam or liquid, and a good thermostat is inserted through the double wall.

The specimen is of length 3-10 mm. and diameter 50-55 mm. and is laid on the hot mercury at the beginning of the experiment. The time (t) is taken before a temperature indicator on top of the plate melts. Indicators are used possessing sharp melting points, such as diphhenylamine (52 degrees) or o-nitrobenzaldehyde (40 degrees). The temperature conductivity is calculated from the equation—

$$a = K.\frac{d^n}{t}$$

In this (k) is a constant determined by calibration and (n) is a value determined by experiments with plates of different thicknesses and the same material; (n) is about 1.7.

The procedure is suitable for a succession of experiments, the time for each being about a half to two minutes, and with care an accuracy of 5 per cent. is obtainable. A glass plate of known temperature conductivity can be used for the calibration. The method was originally proposed for testing ceramic insulators.[8] A disadvantage is having to work with hot mercury, and it is also difficult to keep the surface of it clean. A slight dirtying of the mercury will cause (as may be shown by measurements on glass plates) a bad contact with the plate and,

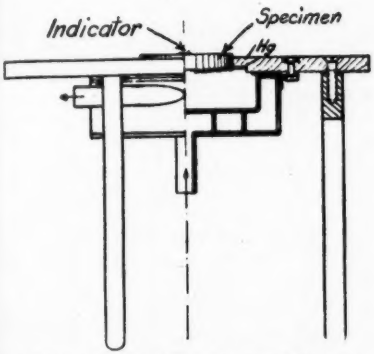


Fig. 4.—Pyk and Stalhane's transfer plate.

consequent, added resistance to heat transfer.

As the thermal conductivity is to be calculated as a product of the temperature conductivity, specific heat, and weight of the specimen, a determination of the specific heat has yet to be made.

(b) **Steam Calorimeter**

Gottwald[10] has developed a simpler version of Bunsen's steam calorimeter,[9] which succeeds in measuring the specific heat as well as temperature conductivity in one operation; it is shown in Fig. 5. In the calorimeter, which consists of a glass cylinder with bakelized paper plates on the top and bottom, are led two pipe lines; the steam enters through one, and the condensed water is led out of the other. The specimen, a rod of 10 × 15 × 60 mm.[11] or a disc[12] is hung by two copper wires, which serve to join both junctions of thermocouples in the calorimeter with the galvanometer. The first junction is surrounded with water in a boring 1 mm. wide in the length of the specimen and the other is left free in the calorimeter. The difference between the inner and outer temperatures of the specimen is thus measured. The two copper wires are fixed to a balance so that the weight of the specimen during the experiments can be determined. In order to catch condensed water dropping from the specimen an aluminium dish is used, and on this is stuck a piece of blotting paper.

From the general differential equation the conduction of heat for a temporary flow of temperature in the specimen is represented by an expotential type of function. In the latter part of the rise in temperature, all terms beyond the first in the series can be neglected. The difference θ between the temperature at the centre of the specimen and the calorimeter follows the equation—

$$\theta = Ae^{-K.a.t.}$$

In this, A is a constant, and K is a function of the dimensions of the specimen. For prism-shaped rods with sides of length l, m, n,

$$k = 2\left(\frac{1}{l^2} + \frac{1}{m^2} + \frac{1}{n^2}\right).$$

For cylinders and discs of length or thickness l and radius t,

$$k = \frac{\xi^2}{r^2} - \frac{\pi^2}{l^2} \text{ where } \xi = 2.405.$$

For the experimentally determined rise of temperature in the centre of the specimen the constant (k.a.) can be calculated and, hence, the temperature conductivity. Since all the dimensional characteristics are not included in this calculation, the value obtained must be multiplied by a correcting factor, which depends on (k), and which can be determined by experiment. For a rod this value is between 1.18 and 1.20 and for a disc it is 1.22.[12] In order to determine the specific heat, the specimen must be weighed in the calorimeter at the beginning and end of the experiment. This gives the weight of steam condensing on the specimen, which is heated from the initial temperature to

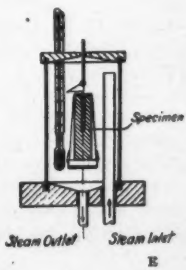


Fig. 5.—Gottwald's steam calorimeter for the dynamic estimation of thermal conductivity.

that of the steam. This weight is multiplied by the latent heat of evaporation of steam (540 cal./grm.), to obtain the quantity of heat supplied. Since the weight of the specimen and the temperature difference through which the specimen heated are known, the specific heat may be calculated.

The heat capacity for the whole suspended arrangement can be established by a single determination. The variation of weight in air and steam due to buoyancy must be borne in mind. For a rod 10 × 15 × 60 mm., the correction in weight amounts to about 6 mgs., which is about 1 per cent. of the weight of condensate.

The apparatus is simple and easily erected. The necessary galvanometer, which should be provided with a luminous pointer, needs a sensitivity of only 8 mV. at the ultimate deflection and does not need adjustment. The time of estimation depends on the shape and conductivity of the specimen, and amounts usually to 10 minutes; the method is thus suitable for consecutive measurements. It is, of course, unsatisfactory for materials with softening points under 100 degrees. For the determination of the specific heat methanol (B.Pt. 65 degrees) may be used, though the temperature conductivity cannot then be measured with sufficient accuracy. The temperature conductivity can be reproduced with an accuracy of at least 3 per cent., and the specific heat about 1 per cent.

Summary

The methods given here are those generally known and those of practical importance. Other methods of uncertain value, or of limited application, have been omitted as being outside the scope of this paper.

The choice of method depends on the purpose in mind. One important consideration is the ultimate accuracy, and in this respect the method of Erk, Keller and Poltz is by far the best. It is also as well to appreciate that the accuracy will be affected by any changes induced in the material during measurement.[13] Since it is necessary to subject the plastic to a higher temperature than is needed for the commencement of elimination of water, a variation may be produced in it which can alter the accuracy by from 1 to 2 per cent. From this aspect, the time of measurement gains added importance. The changes are least when the time of measurement is small, and so a dynamic method will be preferable to a static. The steam calorimeter has the further advantage that it is not limited by the size of the specimen.

On the other hand, static methods come into their own for exhaustive investigations, when some advantages due to the longer time for measurement are gained. For such purposes it is also desirable to attain a higher accuracy, and here the oldest method developed for plastics (Batsch and Meissner) has been superseded. A disadvantage of dynamic methods is that the choice of a top temperature is more limited than is the case for static methods. However, it is an advantage for many purposes to know the temperature conductivity and specific heat of plastics separately.

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Tolerances for Plastic Moulded Screw Threads

A critical review of recent investigations and suggestions on this subject which cannot but result in important repercussions on the standard of mouldings.

WHAT will no doubt prove to be a notable step towards the establishment of a much-needed set of officially recognized working standards has just been initiated by British Industrial Plastics, Ltd., in sponsoring the investigations of Mr. J. Butler and publishing the results in the treatise of the above title.

Purpose of the Investigations

These important published results, one tions has been three-fold. First, to formulate an acceptable scale of working tolerances for screw thread dimensions where both parts are plastic mouldings. Secondly, to evolve a simplified and more accurate method for ascertaining the precise amount of outside diameter alteration on threaded portions of a mould, in order correctly to account for material shrinkage effects. And, thirdly, to urge the acquisition by the mould manufacturing sections of the trade especially of specialized automatic machine tools having incorporated provisions for pitch compensation on all threads, so as to correct endwise contraction and possible pitch deviation in the moulded product.

There is, of course, no universally accepted set of standard tolerances for plastic moulded threads. The position is, rather, that each manufacturer tends to work almost exclusively to his own standards acquired, it is true, often from long and painful experience. This does lead to many difficulties, however, not least being the mystification of many would-be users who are accustomed to think and work in accordance with long-recognized engineering tolerances of size and fit control.

Prevailing methods for obtaining the requisite compensation of thread diameter to overcome subsequent shrinkage variations are rarely accurately calculated, but are usually determined roughly by rule of thumb, or repetitive cut-and-try methods. Such methods are notoriously costly, protracted, wasteful and inaccurate.

These important published results, one understands, are offered to moulders generally for fullest critical examination, and detailed study, in the hope that undesirable features, inconsistencies, errors, etc., will be uncovered and amended in the light of whatever constructive criticism is afforded to these proposals. At a not-too-distant date, the author hopes, there may thus arise a sufficiently well-informed measure of agreement to ensure the ultimate adoption of a complete scheme of screw-thread tolerances for the general use of the whole moulding industry.

These are meritorious aims if for no other reason (although many other sound ones could be advanced) than to eliminate many non-standard standards and some of the purely parochial systems of tolerances at present so inadequately serving the industry.

As mentioned, current practice adopted by mould makers for securing compensatory allowance of mould threads to cover shrinkage is largely based on practical experience of similar component designs, material used, and general moulding procedure. This usually enables a passable thread to be secured. Where strict accuracy is required, provision is often made on thread sizes for leaving a fine shaving cut to be taken off by a sizing die after moulding. Thus, by this inexpensive but admittedly makeshift method, do many manufacturers produce precision threads.

In the first outlining section of Mr. Butler's monograph, the chief effects

upon thread sizes arising from material shrinkage are described. As is well known, these are two-fold, viz., pitch deviation and loss of effective diameter. The former arises by reason of the endwise contraction of the moulding during cooling, and is obviously far more serious and difficult to eradicate than the latter, which is readily adjusted by slightly enlarging the outer diameter of the threads in the mould.

General Tolerances and Determination of Diametrical Compensation

Ensuing sections are devoted to an explanation of the two separate schemes of general tolerances, and the accurate determination of diametrical compensation. This latter, incidentally, Mr. Butler envisages purely as a provisional plan to bridge the interim between the present and such time as when the industry will be equipped with precision tools of such a kind that automatic compensation for both pitch and diameter can be provided on any mould thread.

This latter will not only be dependent upon machine tool manufacturers being able to develop suitable and satisfactory designs of such tools, but also—and perhaps mainly—upon the creation of a sufficiently substantial demand among mould makers to render such development work worth while.

Such a demand does not exist at the moment, chiefly because few moulders are called upon to furnish precision-threaded mouldings, and those having to perform such jobs are content to employ existing methods, as already explained.

Considering the questions of general working tolerances, Section 2 lays down some basic considerations, rightly based upon the need for maintaining accuracy of the effective diameter of a thread, upon which factor the scales of permissible tolerances are built up. Mr. Butler is undoubtedly on sound lines in this respect.

There is next explained in detail additional factors which give rise to errors in mouldings, and the requisite allowances in the suggested scheme of tolerances which Mr. Butler affords them. It is interesting to study this carefully. They are:—

(1) Errors in Toolmaking.
(2) Tool Wear in Long Runs.
(3) Variations in Powder Shrinkage.

(1) Errors in Toolmaking.—Mr. Butler states that " toolmaking errors are, or should be, considerably less in making threads than in making the rest of the mould."

But this is surely only true in such mould designs embracing the complete threaded portion within one block. In cases where the thread is of the " split " type, both blocks especially will have to be machined, fitted, aligned, and so maintained to a comparable degree of accuracy to that imparted on the threads themselves. Otherwise, block misalignment, warpage, error or wear will seriously affect the accuracy of the finished threads. Thus it would be safer to assert that all portions of thread-forming moulds should be as close as practicable to the accuracy and finish of the thread matrix itself.

Mr. Butler next postulates that " the accuracy of formed threaded portions of a mould should approach that of screw gauge making, but does not reach it." To achieve this desirable end, it is considered that mould makers could work to dimensional tolerances of 50 per cent. more than those permitted by the British Standards Institution tolerances for screw gauges.

Arising out of this basic assumption, three grades of tolerances are proposed, thus, fine, medium (twice fine) and coarse (four times fine). The suggested tolerance in the fine class to cover toolmaking errors on components up to 1 in. diameter is, therefore, laid down as follows:—

Female threads: Plus .0009 in.
Male threads: Minus .0015 in.

For every additional 1 in. of diameter increase, tolerance increments equal to two-thirds those for 1 in. are proposed.

This appears to me a much too steep incremental rise. To illustrate, take a 4-in. diameter male thread to fine tolerance limits. On the above basis the permissible toolmaking allowance will thus

be .0045. Viewed from even existing tool-making standards, this would scarcely be regarded as a precision job. Actually, it is almost as easy to cut a large-diameter thread to accurate limits as a small one.

To meet such a criticism, I would suggest that the incremental addition to the tolerance for every 1 in. increase in diameter be only one-fifth the tolerance of the first 1 in. diameter. Taking the previous example of a 4-in. diameter thread, the permissible working tolerances would then be .0024 for fine fits. For medium-grade fits it would be .0048, and for coarse-grade ones .0096. Compare these with the set of tolerances afforded by Mr. Butler's scale, i.e., .0045, .009 and .018 respectively.

(2) Tool Wear.—One wonders whether it has been altogether wise to relate this tolerance factor " directly proportional to circumference and diameter " at the scale of .001 per 1 in. of diameter.

Surely tool wear will bear a far greater relationship to the area of threads contacting the product. Thus, a fine-thread form of shallow depth will be subject to far more rapid wear than one of coarse pitch and ample depth, because the frictional pressure and any abrasive action set up will be distributed over a larger flank surface area in the case of the coarse thread.

Again, is it stating the complete case to aver that wear is chiefly due to abrasive action arising when unscrewing the finished moulding? Very considerable wear is often occasioned in mould threads by sluggish flow of material, excessive heat or pressure, bad surface finish of mould cavity, and so on. All these factors will interfere with the free flow of material causing additional friction and rubbing of thread form.

As regards the actual tolerance set down by the author, i.e., that of .001 in. per 1 in. of diameter, this, again, is apt to prove excessively large on big diameters and inadequate on small ones. Instead of being directly proportional to diameter as stipulated, it seems a more reasonable basis would be to bring it into closer relationship to area of threads, and I suggest this point as one well worthy of further investigation.

(3) Powder Fluctuations.—It is certainly difficult to accept with the same certitude as Mr. Butler his statements about the ability to control powder fluctuations. Many factors other than composition operate to condition the degree of fluctuation. Thus, to allow a moulding to remain too long within the mould will cause unequal shrinkage and distortion, which, in many instances, will seriously alter dimensions. Delay in the withdrawal of a threaded core may also create variations, leading to mal-formed threads or permanent distortion. To my mind, all these operational factors require consideration and perhaps proper allowance in any set of tolerances, because moulding, as yet, is not a mathematically precise procedure.

Component Distortion

In the list of basic general factors determining tolerances, it seems Mr. Butler has overlooked the one of distortion. It is well known that the degree of accuracy of a thread form especially is, to a very material extent, dependent upon the minimum of distortion. I believe this is an aspect of moulding which deserves more consideration and examination in all its effects, and one which would certainly reveal the advisability of making allowance in any set of size tolerances.

Useful tables of general moulding limits are presented covering common types of thread forms, and these will clearly prove of convenience to the moulder.

Sections 3, 4, 5 and 6 deal in turn with tolerance needs created by various combinations of moulded threads and mating members, where these are in metal, and adjustments are suggested to the plan of general tolerances whereby those special requirements can be easily met.

In all cases where a moulded thread engages with a metallic one, greater accuracy is needed in moulding the former, hence the need for the control and neutralization of pitch shrinkage. To meet such requirements, Mr. Butler has developed useful formulæ whereby the

exact amount of diametric increase to ensure free and correct mating of such threaded parts can be calculated.

This would undoubtedly prove of great assistance to the mould designer and maker and would permit great savings in machining times, a departure from old cut-and-try methods, and greater assurance of resulting accuracy.

One very important point not fully dealt with in the monograph, but which will inevitably arise, refers to the gauging of pitch-compensated cut threads of a mould. Standard gauges cannot be used of course, and it seems that a mould maker will be faced with the task of providing some efficient means for gauging thread sizes, either by special measuring equipment or a system of numerous thread plug and ring gauges. This would prove a costly business, especially when coupled with the purchase of possible automatic thread compensating machines of the kind Mr. Butler has in mind. Where compensation is made to diameter only, as at present, standard thread gauges can be used to check pitch, form, angle, and so on.

Notwithstanding the forementioned criticisms, or, rather, suggestions for further investigations, British Industrial Plastics, Ltd., and Mr. Butler together have certainly succeeded in building an extremely sound foundation for a comprehensive study of this important aspect of moulding practice, and one is sure that this effort will engage the sympathetic interest and constructive criticism of many within the industry, which will, one hopes, speedily lead to the formulation of a core of accepted official general tolerances, and procedure of thread compensation to meet the peculiar needs of the industry. W.M.H.

Suction Filling by Plastic Tube

THE problem of filling containers with silica or siliceous materials has long been studied from the point of view of hazard to workers. When filled by gravity into small open containers, as so commonly occurs in the abrasive and abrasive soap industries, the danger of silicosis is by no means negligible even in the most efficient works. The best means of avoiding such a danger is to maintain a totally enclosed system under vacuum.

The Breslee Mfg. Co., of New York (according to "Modern Packaging") has installed such a plant with complete success for the packaging of asbestos powder, with the novel use of a transparent flexible plastic tube. On the right of the accompanying photograph the tube leads from the hopper containing the asbestos powder to a totally enclosed weighing machine which holds the package, and which is maintained under vacuum.

The plastic tube is of extruded Saran (polyvinylidene chloride), a product of Dow Chemical Co., Michigan, U.S.A. Apart from the obvious advantage of the use of a flexible tube, its transparency also allows the flow of powder to be visible and enables the operator to observe the working of the system. Furthermore, it has been observed that, in contradistinction to metal tubes, there is no adhesion of the power to the plastic surface during transit because of the smoothness of the latter.

Polyvinyl Chloride for Prostheses

The Modern Technique of Building-up Facial Wounds

POLYVINYL chloride (p.v.c.) compounds have found many and interesting applications during the war, notably for the sheathing and insulation of cables and for the proofing of fabrics. Particular significance in present circumstances is its utilization in the preparation of surgical prostheses, such, for example, as noses, ears and fingers. War unhappily produces a large number of disfiguring injuries, which severely tax both the skill of the plastic surgeon and the endurance of the patient. Treatment of such injuries generally involves a long series of operations and continual nursing care, during the course of which the ability of the patient to co-operate may be impaired by the realization that he appears frighteningly disfigured. In addition to loss of tissue due to burns and injury there is often a further loss by disease, which it is generally impracticable to remedy by reconstructive surgery and necessitates some form of false features or prostheses, as it is known to the plastic surgeon.

Raw Materials of Prosthesis

Prostheses have been made from metal painted to resemble tissue, gelatine-glycerine mixtures, vulcanite, wax, dental acrylic resins and rubber latex. Of the hard materials, dental acrylic resins, such as "Kallodent," if prepared with skill, give the best result in cases for which a hard restoration is suitable, whilst rubber latex provides a good but much less permanent restoration. These prostheses may be attached to the face with adhesives or may be fitted to the frame of a pair of spectacles. Naturally, when the attachment is to the skin by means of an adhesive, the weight of the restoration must be small. Imperfections in fitting of the appliance and matching are generally corrected by cosmetic creams and powders, and the fatty basis of the cream may have a destructive effect on the fine edge of the rubber latex restoration. There is also a tendency for prostheses made from rubber to darken on ageing.

In view of the inertness and flexibility of plasticized polyvinyl chloride compositions, it was thought that they should be suitable for making prostheses. A considerable amount of work has, therefore, been done on the material by Imperial Chemical Industries, and is recorded here with the aim of assisting those who wish to pursue the investigation.

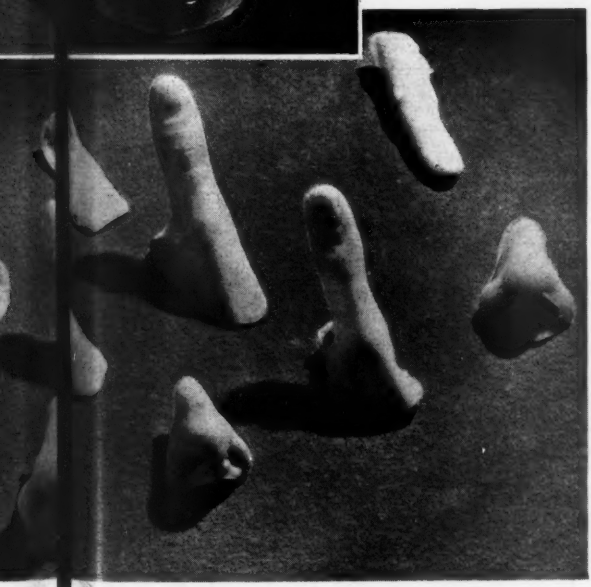
It is well known that polyvinyl chloride swells in the presence of plasticizers such as tricresyl phosphate, dibutyl phthalate or dihexyl phthalate, and may be dissolved at elevated temperatures to form flexible rubber-like products. The physical properties of the resultant materials depend both upon the proportions and upon the type of plasticizer used. The completely "gelled" plasticized compositions are thermo-plastic and can be moulded by compression or injection methods. Polyvinyl chloride-plasticizer mixtures can also be prepared in the form of pastes, varying in consistency from thick cream to that of putty. These pastes can be transformed by heat to flexible rubber-like products, and shaped during the process by a simple moulding operation. It was considered that this technique would be particularly suitable for making prostheses, which are often complex in form and of varying thickness. It was realized, however, that care would have to be taken in choosing the most suitable ingredients for the composition for use in contact with the human skin. Tricresyl phosphate is very often used as the plasticizer in polyvinyl chloride pastes, but for this application it was decided to use only phthalate esters as plasticizers, e.g., dibutyl and dihexyl phthalate.

(Continued on page 576.)

BUILDING-UP YOU WITH POLYN

The occurrence of severe facial and other wounds has led to a new technique of replacing destroyed features by plastic mouldings. So successful are the modern methods and so accurate and—

P OUNDS
OL NYL CHLORIDE



—imitative are the mouldings that happily no disfigurement can be readily seen. The above photographs show the simplicity of the process and some of the results made with p.v.c. paste.

The following problems were investigated:—

1. Development of a composition suitable for the production of an adequately flexible restoration and having a reasonable shelf life.

2. Development of the best gelation technique, i.e., the optimum temperature required to produce a restoration of the maximum strength. Thin edges may be required for attaching the prostheses to the skin, and are insufficiently strong unless a relatively high temperature of gelation is employed.

3. Finding of a pleasing "base" colour.

4. Development of techniques to secure accurate fitting.

The use of dibutyl phthalate instead of the more usual tricresyl phosphate as the plasticizer involved difficulties in obtaining a paste having an adequate shelf life, and it was finally decided that for the time being the paste should be made from the polymer and the plasticizer immediately before use. Polyvinyl chloride compositions are more flexible when plasticized with dibutyl phthalate than with an equal amount of tricresyl phosphate.

A temperature of gelation of 140 degrees C. was found to give satisfactory restorations, but introduced difficulties due to discoloration of the composition, particularly because of the omission of a lead salt stabilizer. A wide range of satisfactory pigments has not yet been developed, but good results were obtained in a "natural" pink shade by the use of cadmium red together with a white pigment. Initially titanium dioxide was used for this white pigment, but zinc oxide was found to give better colour stability.

Moulding the Restoration

The method of making a restoration, e.g., a nose, is as follows:—

The nose is made in wax or "Plasticine," either modelled to the patient's face or to a plaster mask of the face secured by a moulage method. The wax or "Plasticine" is then invested in one half of a large dental flask in plaster-of-Paris. When the plaster has set the "Plasticine" is removed, and new hot wax poured into the cavity to replace it to a uniform thickness all round the mould, thickening where this is necessary, for example, at the tip of the nose, but realizing that the thicker the wax the heavier the final restoration will be. Plaster-of-Paris is then poured in, and the reverse half of the flask filled with plaster and closed. When this investment has set entirely, the flask is placed in boiling water until the wax is entirely removed. The flask and plaster investment are then thoroughly dried out in an oven, to ensure that the necessary temperature of gelation will be attained. When quite dry the mould is removed from the oven and allowed to cool to a temperature of about 50 degrees C.

A paste is made by stirring pigmented polyvinyl chloride powder with dibutyl phthalate in a mortar until a smooth paste is obtained. Equal parts by weight of the plasticizer and polyvinyl chloride are convenient proportions, but the flexibility of the result may be increased or decreased as desired by increasing or reducing the amount of plasticizer. Ability to form pastes depends on the type of polyvinyl chloride used, and specially prepared "Corvic" polymer was used in these experiments. The mould is then filled with the polyvinyl chloride paste, possibly tinted in addition to match more closely the skin adjacent to the particular restoration. The flask is secured, replaced in the oven and left for one hour at 140 degrees C. After gelation the flask is removed from the oven and allowed to cool, when the restoration is removed and trimmed. The prosthesis may be fixed by means of adhesives, such as gum tragacanth or spirit gum, or by conventional methods involving attachment to spectacles. A better surface is given to the prosthesis when metal moulds are used, but such moulds are less easy to prepare than those of plaster.

Additional paints to assist in the matching of the prosthesis to adjacent tissue have been developed by I.C.I., Ltd.

World's Industry Employs Plastics

AIRCRAFT

New Buna N has been evolved for oil seals, oil rings, etc., demanding resistance to fuels high in aromatics. It remains flexible at – 40 degrees F., and is very resistant to any permanent deformation in compression. A tensile strength of 100 lb./sq. in. and an elongation of over 100 per cent. is retained, even after the material has been subjected to the action of mineral lubricating oil at 300 degrees F. for a period of 70 hours. ("Automotive and Aviation Industries," 1944/91/90.) **Non-skid floor coating** for aircraft is composed of ground cork bonded with about one-fifth its weight of a suitable grade of Thiokol. The material is applied at room temperature with an open nozzle paint spray. The non-swelling properties of the Thiokols in contact with oil are a further recommendation for its use in this particular instance. **Cascophen, a new synthetic-resin adhesive,** produced by the Casein Corporation of America, sets at temperatures a little above those of room level. The material, which can be stored indefinitely at temperatures a little below room level, cures in 8-10 hours at 70 degrees F., or in less time at higher temperatures. **"Doughnut," or "O ring" packing,** is becoming increasingly popular in hydraulic equipment for aircraft. Oil-resistant synthetic rubber sealing of this type enables satisfactory results to be obtained with one ring only, the recess for this being in an appropriate groove in either the piston skirt or cylinder wall of the equipment. Details are given in an authoritative article in "Product Engineering," 1944/15/581.

GENERAL ENGINEERING

Testing methods for organic plastics laid down in U.S.A. Federal Specification L-P-406a of June 24, 1944, supersede those set out in L-P-406 of December 9, 1942. Certain of the testing methods listed appear almost equivalent to already existing A.S.T.M. methods; others, however, have not been specified before. Amongst these are methods for determining bonding properties, shear strength in double shear, bearing strength, flexural fatigue strengths under constant strain and constant stress respectively, creep tests, tests for resistance to shock and shatter, falling ball impact test, Rockwell indentation test, wear resistance and scratch resistance, etc. The study is very comprehensive and contains two mechanical tests, seven thermal tests, seven optical tests, five electrical tests, five miscellaneous physical tests and four chemical tests. **"Metlbond,"** which may be used to bond Plexiglas to aluminium, steel to plastics, aluminium to steel, etc., is an adhesive of recent introduction for which many novel qualities are claimed. It is produced by Consolidated Vultee Aircraft Co. **A vinylite-resin tape,** manufactured under the name "Fibron," is put forward for numerous applications demanding high dielectric strength, high mechanical strength and resistance to momentary impingement of flame. It is stated to be heat sealing. ("Automotive and Aviation Industries," 1944/91/192.) **Analysis of cam-control linkages** is facilitated by construction of model cams from thick cellulose nitrate or acetate sheet. Inner and outer cam

tracks can readily be made in these materials. ("Product Engineering," 1944/15/597.) **Protection of grinding spindles** against abrasives is said to be afforded by brass bellow seals rotating against Neoprene or graphite plates. ("Product Engineering," 1944/15/614.) **Trade mark "Noreplast"** has been given to a series of new moulding compounds developed by the United States Department of Agriculture's Northern Regional Research Laboratory at Peoria, Illinois. The new compositions are very economical in so far as the phenol-formaldehyde resins embodied in them are employed quite sparingly. All formulæ contain 50 per cent. or more ground agricultural residues, such as wheat, straw, flax, shives, corn stalks, peanut husks, etc. The percentage of resin varies between 25 and 47 per cent., with plasticizer from 0 to 15 per cent. ("Scientific American," 1944/77/124.) **Dies for injection mouldings with inserted cores** for threads are discussed by Gastrow in "Kunststoffe," 1944/34/37. The body of a fountain pen was selected by the author as a typical illustration for his argument. **Plastic core binders** are discussed by Grassmann in "Giesserei," 1943/30/246. The author infers that the substitution of synthetic resins for the conventional starch-drying oil mixtures caused considerable difficulty in the earlier stages. Phenolic resins, both plasticized and unplasticized, alkyd resins, the reaction products of alkyd-phenolic resins and oils, urea resins and certain by-products of wood oil are considered in the light of their suitability as core binders. Strong cores for iron foundry work can be made of cement with methyl cellulose and calcium chloride. The harder phenolic resins may also be employed. For hand-made cores and blown cores urea resins may be employed, with the possible addition of starch and methyl cellulose or of methyl cellulose combined with other plastics. The phenolic resins show good strength properties when dry and do not gas. They lack, however, the plasticity associated with the conventional oil-bound sand cores. Urea resins in both the dry and green states have good strength properties. The cellulose compounds are satisfactory when dry, but are somewhat difficult to desiccate to the required degree, whilst their permeability to gases is restricted. **Injection moulding plant for thermoplastics** will probably shortly be standardized in Germany. Four different types have been fixed on the basis of pressure range. Formerly 14 types were employed. In order to economize in labour, the production of hand-operated machines demanding the application of much physical strength has been stopped until further notice. Dimensions of dies have been standardized in so far as mounting and fixing is concerned, in order to permit transference of dies from one machine to another. (V.D.I. Zeitschrift, 1944/88/111.) **Test plant for proofing of plastic bearings** is described by Conradt. The device is commendable in that actual bearings of normal design may be subjected to test. An account in "Kunststoffe," 1944/34/79, gives a full description of the apparatus and the measuring equipment attached to it.

SHIPBUILDING

Melamine plastic with glass fibre reinforcement is recommended for the construction of electrical control panels for use on board ship in order to reduce fire hazard. This material, which has been adopted by the American Navy, has high impact strength and high resistance to the carbonizing effect of the electric arc. ("Machinery," New York, 1944/50/228.) **Plastic-impregnated wood-pulp mass,** manufactured by the Keyes Fibre Co., is stated to possess extremely high impact resistance. It has found a notable use as a replacement material for aluminium in the production of valve handwheels on destroyers; its thermal conductivity is less than 1,000th that of aluminium. It is not affected by boiling water for periods of immersion up to 24

hours, and successfully withstands prolonged exposure to temperatures as low as −40 degrees F. It is little affected by lubricants and petroleum, and its overall mechanical strength is high.

ELECTRICAL

Water tightness of flashlight issued to U.S. Navy is provided by tapered projections moulded on to the side walls and end caps. These projections press down on small rubber washers inserted between the body and the caps. The body of the flashlight is in cellulose-acetate butyrate. ("Product Engineering," 1944/15/597.) **New synthetic rubber latex mix** for electrical insulation has been developed under the trade name "Nubun." The polymerization of the synthetic rubber base is controlled to within close limits and the mix contains a carefully regulated proportion of styrene. The material is processed in such a way that it is given improved working and insulating properties. "Nubun" is produced by the United States Rubber Co. **Plexiglas masking jigs** are finding extensive use in the copper-plating of carbon rings. This material has been adopted owing to the ease with which it may be machined, its freedom from distortion and light weight. Percentage of scrap has been reduced as a result of adopting this masking system. The jigs are both mechanically durable and resistant to this plating solution and other mild baths. **Resinox 7934,** a new type phenol-formaldehyde resin with mica fillers, is claimed by Monsanto Chemical Co. to possess valuable dielectric and power factor constants, making it useful as an insulating medium in high-frequency apparatus. **Feed-through terminal block** for electrical devices requiring external terminals is moulded in bakelite, and provided with special moulded-in metallic inserts. The block is produced by Curtis Development Co., Chicago.

CHEMICAL

Properties and applications of Keebush, a compound on a phenol-formaldehyde base with specially treated chemically inert fillers, are discussed by Gilbert-Rolfe in "Practical Engineering," 1944/10/242. The material is produced by the Kestner Evaporator and Enginering Co., London. Among the specific applications of this material cited are cylindrical and rectangular tanks, pipes, general fittings, valves, pumps, fans, die trays, crystallizing pans, components for textile dyeing, and finishing machinery, and equipment for handling acids.

MISCELLANEOUS

Heat resistance, thermal conductivity, age-shrinking, thermal expansivity and specific heat of commercial types of plastics are discussed by Larson in "Product Engineering," 1944/15/581. The account is supplemented by a bibliography on the influence of temperature on moulded phenolic materials. **Saving of 5,000 tons of natural rubber** was achieved during the first four months of the current year by the U.S. Army Signal Corps, which has replaced much of the natural product with carefully selected synthetic and alternative materials. **Use of horn waste** as raw material for plastics has been investigated by the Indian Synthetic and Industrial Research Council. **Stabilizers and pigments** used in the production of "Koroseal," the polyvinyl chloride product manufactured by the Goodrich Co., are dealt with by Groves in "Practical Engineering," 1944/10/382.

Plastics in Tool, Jig and Fixture Construction

The author continues his paper with the production of dies using plastics and of tools made from laminated materials

By E. E. HALLS

ANOTHER direction in which plastics have been called upon in recent years to augment the efficiency of the toolroom was covered by an article in " Plastics," May, 1944, p. 229, entitled " A New Process for Making Moulds by Electro-deposition," contributed by P. Spiro. In this, the plastic takes the very primary role of providing the material from which the master part is machined. The nature of the plastic chosen can be determined by the intricacy of the object. In general, one of the most readily machine-able materials would be selected, such as cellulose acetate, but it need not be restricted to this by any means, and, in fact, it may, in some cases, be desirable to use a thermosetting plastic, such as cast resin, laminated material or a filled moulded type. This machined article serves as the negative of the tool, which is then made by carefully carrying out a number of operations, some of which sound rather intricate, yet in practice they are apparently reasonably simple. The plastic article is electro-plated, and this coating is backed up by a sprayed metal coating. The shell so formed is removed from the article, fitted into a metal " frame," and the interspaces filled with metal to give a solid tool. Some brief notes from the patent which covers the procedure can usefully be given, because from these can be visualized just what is involved as well as the claims made.

British patent No. 550,563, dated January, 1943, due to A. O. Frankenthal, E. Kohnstamm and the London and Scandinavian Metallurgical Co., Ltd., covers the manufacture of moulds by making a negative from an easily machineable material, then electro-plating, metal spraying and backing with another metal. The actual claims are as under:—

(1) For a mould for use in pressing, die-casting and injection moulding operations, and actually covering an electro-deposited shell which constitutes the working face, with backing of high melting-point metal applied by spraying, and a further metal backing cast into position.

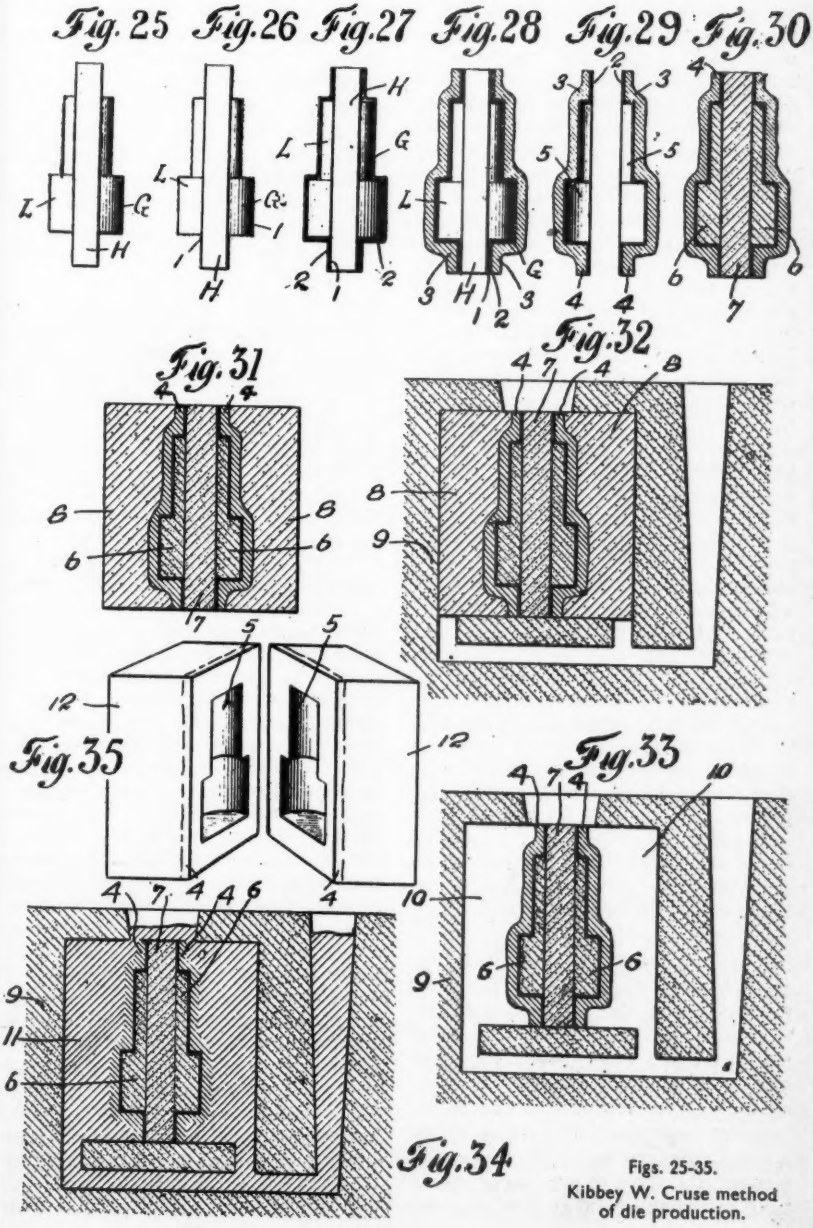
(2) Nickel or nickel alloy for the working face and steel or cast iron for the metal backing.

(3) The electrolytic polishing of the working face followed by chromium plating.

(4) A readily destructible material for the pattern, such as cellulose acetate.

(5) Pins embedded in the pattern and projecting to correspond to holes as desired in the final job.

The invention is intended to relate to any moulds for use with plastic materials or with metals, and to cover operations of pressing, injection moulding and die-casting. The pattern required is a negative of the mould desired, i.e., a positive of the actual job to be pressed or moulded. It can be made from easily workable or machineable material, such as plastic, plaster or wood. The surface of this pattern then has to be made conductive in the normal manner. For example, it may be degreased by suitable processes, such as scouring with lime, and rendered conducting by immersion in one of the customary silvering solutions. Any portions that are not required to be electro-plated can be cleaned with nitric acid to remove the silver, or covered with stopping-off lacquer.



Figs. 25-35.
Kibbey W. Cruse method of die production.

The pattern is then nickel-plated by suspending by means of a number of nickel-plated copper wires, which, as far as possible, are attached at points which do not fall within the ultimate working surface of the mould. The copper wires may be coated with stopping-off lacquer if desired. Also the pattern should preferably be rotated slowing, a speed of one revolution per hour being mentioned.

Plating conditions are maintained to give rapid deposition of a hard, even deposit, free from stresses and free from pitting or any of the well-known defects. A plating thickness of from 2 to 4 mm. is indicated. Any pins inserted in the pattern thereby become held tightly in this deposited nickel and become inseparable from it.

Phenolic plastics or cellulose acetate are suggested for the pattern. Cellulose acetate is particularly mentioned because it is so readily machineable and the pattern can be built up from machined parts secured together by softening the abutting surfaces with acetone. Further, when the pattern has been built up, it can be coated with acetone to give the equivalent of the high polish all over its surface. Also, pins, for example, of steel, can readily be assembled accurately and firmly to a depth corresponding to the depth that they have to project from the final mould. At least one-third of their length should project from the pattern.

The electro-deposited shell is removed from the pattern by suitable means according to the nature of the pattern; for example, by melting, burning or by mechanical means.

It is next advisable to roughen the surface of the shell by one of the usual means, such as abrasive blasting normal to metal-spraying technique. The shell is then sprayed with a layer of steel by holding it in a frame with a few mm. clearance; cast iron or steel can be fed into this interspace and cast on to the sprayed metal coating. Produced in this manner, the faces of the mould should have exceedingly good surfaces, because there are no machine marks. However, these faces can then be polished electrolytically, and, providing any silver remaining on them is removed by anodic etching in cyanide solution, the surfaces can be chromium plated. It is claimed that the chromium adheres extremely well to the surfaces.

A.P. No. 1,912,889, by Kibbey W. Couse, March, 1931, is cross-referred to by the previous patent. The object of this patent was to produce dies for die-castings and the like, having great accuracy of form, high quality, and durability at low cost. The substance of the patent is illustrated by drawings, which are reproduced here to show the stages involved:—

Fig. 25 is an elevation of a pair of half-masters mounted on a carrying plate. Fig. 26 is the same after surface treatment. Fig. 27 shows the next stage, whereby a coating of metal is applied. Fig. 28 shows building up by a further coating of metal. Fig. 29 is a sectional view illustrating the several coatings, now constituting a pair of half-shells. Fig. 30 is the same except that the half-shells are filled with refractory material and mounted on a carrying plate. Fig. 31 is a similar section as Fig. 30 with the parts filled with a suitable removable material. Fig. 32 shows how the parts would appear in a mould, and Fig. 33 is the same again with the removable material already removed. Fig. 34 is again the same with removable material replaced by metal. Fig. 35 shows in perspective the mating pair of metal die blocks when completed. The following explains the lettering:—

L and G are two half-masters arranged in proper mating relation at opposite edges of the carrier plate H. L, G and H may be of any appropriate material, such as wood, composition, metal, etc. The dotted lines 1 in Fig. 26 represent a light coating of grease applied to the opposite side surfaces of the two masters. In Fig. 27, 2 is a light flash copper coating applied electrolytically, and 3 in

Fig. 28 is a nickel coating. It is indicated that layers 2 and 3 are preferably applied by electro-deposition or spraying. The thickness of the nickel coating is substantially to permit lifting away of the half-shells from the opposite sides of the masters.

The cavities 5-5 in Fig. 29 are identical in shape with the exterior surface of the parts L and G. In Fig. 30, 6 is fire clay, carbon paste or similar material filled in and dried by mounting in back to back on a carbon plate. Next the shells are built up with wax 8-8, and mould 9 rammed up as shown in Fig. 32. The wax is removed by melting and drawing off. The mould is then filled in the usual manner with suitable molten metal 11, such as iron, steel, bronze, thermit nickel steel, etc. Using nickel as the shell parts and thermit nickel steel as the filler, alloying between the two occurs. Finally, filler 6 is removed, leaving the completed pair of die blocks as shown in 12-12 of Fig. 35.

It is pointed out that an intentional feature of this American patent is the alloying, which can occur between the filler metal 11 and the metal 4/4 which comprises the shell, this alloying resulting without breakdown of the shell parts. It also stresses that the impression cavities 5/5 in the final tool are of precisely the same contour as the masters L and G from which produced, and that any number can be produced from these same masters with the assurance that all will be identical. Again, it states that the metal-deposited walls of the impression cavities can be of any suitable metal, and the material of the die blocks may likewise be chosen from a range, provided the purpose for which the finished tool is intended, and production cost, are borne in mind. If intended for casting metal of high melting point, then the materials used must, of course, have a high melting point. For lower melting casting, correspondingly lower melting and less-expensive materials for the tool may be considered. Again, the patent covers the use of shells for 4/4 produced by any other preferred means, such as stamping a pressing from sheet metal, or, again, the refractory material 6/6-7 may be used as the master if desired.

It will be seen that there is a large interval of some 12 years between the two patents, the more-recent one indicating substantial advances in the art. The use of plastic masters is one of these; the building up of a thick plating on the plastic has been made possible by developments in the electro-deposition upon plastics, and the reinforcement of this plating by sprayed metal is another sign of the progress made.

The original article in "Plastics" should be consulted on this subject because it gives illustrations of a tool built up in this way and of a moulding from it.

The primary advantages are relief to the toolroom, less-experienced labour and quicker tool production. It is too early to state authoritatively what serviceability can be assured. For short runs, this type of mould is fully justified and often enables articles to be moulded or cast, whereas normally tool charges could not be justified. For castings, better surface finish can be expected, and for the lower melting point materials such as zinc-base alloys and the tin babbit metals, it may be that greater advantages will accrue than with the aluminium alloys. Naturally, the tool cost saving is greater when alloy steel dies are replaced than when the more easily machineable cast-iron ones only are involved.

Again, in any case, a technique has to be acquired, the plating of plastics is not so simple as electro-deposition upon metals. Comparatively thick electro-nickel coatings demand special technical control and skill, and, naturally, the metal spray coating applied to the electro-plated shell has to be properly keyed.

Fabrication of Tools, Jigs and Fixtures from Plastic Stocks

Probably the first counts that direct attention to plastic "stocks" for tools, jigs and fixtures are light weight and machineability. The specific gravity of the average plastic material is 1.25, as

compared with 7.8 for the steels, this ratio of 1 to 6 meaning an appreciable saving in weight. The specific gravity of some plastics suitable for the purpose is as low as 0.9; a few may be as high as 1.75 to 2.0. This saving in weight signifies much more than appears at first sight, particularly on large tools. There is not merely the manual effort expended during the manufacture of the tool itself that is concerned, but also that involved in repeatedly setting up or breaking down of the tool, periodic reinspection, repairs and transportation to and from store.

Machineability means much because the plastics are relatively easily machined, and much time is saved in toolroom labour, which is a very important factor to-day. No heat treatment is involved with the plastics, and, of course, in the usual sense no heat treatment is practicable. There are no rusting or corrosion troubles, and, therefore, no oiling or greasing is required for preventing deterioration from these causes.

The plastics are attractive because regular "stock" materials cover not only a range of types, but also of forms. Probably the phenolic resin materials are the most widely useful, and these can be procured as laminated plastic in which the laminæ may be paper, fabric, wood or asbestos, each in several grades. They can also be procured as cast resin or moulded products. Not only is sheet material securable, but also sections, rod and tube, with the latter round or square.

Each plastic has its possibilities and its limitations, and, naturally, the latter must not be ignored. Further, a material which is eminently suitable under one set of conditions is not necessarily best for the same job under different circumstances, especially when it is remembered that the latter must include factors such as quantity of the article to be produced. Therefore, it is again stressed that plastics must not be looked upon as an all-purposes tool material.

Again, plastics in this application must not always be considered in respect to the replacement of metals. Much wood is employed for jigs and fixtures, and the plastics have many advantages over wood. Handleability and durability, and better resistance to dampness or water contamination, are some of these. They may not necessarily be so economic, so, again, no over-riding conclusions should be drawn.

Perhaps the most widely employed plastic of this group, used for jigs, tools and fixtures, is densified laminated wood, densified by means of synthetic resin of the phenol formaldehyde type. The material referred to for this purpose is a development of recent years, and it has proved itself invaluable in the aircraft industry. In fact, it is probably correct to say that, without this material, the stupendous production capacity attained in this country would have been out of the question. These resin-densified woods have been made in various resin contents and under differing pressures, with a corresponding range in specific gravity from 0.9 upwards. It is the low gravity, lower resin content materials that have proved of such value. The higher resin content materials, of course, have been known for many years and are almost indistinguishable in general appearance and hardness from the phenolic laminateds having paper or fabric filling. They, too, have their field, especially as insulation in electrical applications.

The densified laminated woods have been given some publicity in the technical Press. Thus, in "Plastics," March, 1943, p. 122, A. E. L. Jervis contributed to the subject under the heading of "Resin Laminated Densified Wood." Other articles by the same author are as follows:—

"Densified Laminated Wood for Jigs," "Machinery," December 17, 1942.

"Insulating Wood," "Electrical Review," November 6, 1942.

"Laminated Densified Wood," "Electrical Review," March 27, 1942.

Another paper on the subject is "Densified Laminated Wood for Engineering Uses," which appeared in "The Engineer," September 11, 1942.

From these, some data and illustrations are reproduced in the following to add to that already given in "Plastics," in so far as it is apt to the present review of the subject.

The particular brands of densified wood referred to in the above were first introduced into this country by Bruno Jablonsky, and developed commercially by Moulded Components (Jablo), Ltd., of Croydon, Surrey. Their light-density material is known as Jabroc, this being the special tool material, while their high-density one is Insul-jabroc, a material with special attributes for electrical and mechanical engineering purposes.

Primary Requisites

Uniformity of properties and characteristics are essential in a composite material such as resin densified wood if it is to earn a place as a toolroom material, a key position in engineering factories, to gain the confidence of engineers, and to maintain both the position and the confidence. Uniformity of production is therefore an important factor, and it will quickly be realized that there are a number of special problems which arise and which must be solved and controlled.

This type of material is built up from veneers or laminations of certain woods, the laminæ being bonded together with resin under high pressure between heated platens. The type of wood to select; the quality of the veneer or lamination and its thickness; the nature of the resin bonding agent; its mode of application and quantity employed; the pressure to be applied; the temperature of the platens; and the time period in the press: these are the more obvious of the variables that have to be studied, the best conditions determined, put into production practice and controlled in repetition manufacture. One set of conditions may not best suit all purposes with respect to final application, and, hence, there can arise a number of grades and the necessity for a clear system of distinguishing them. From the published literature referred to, it is stated that the various woods that can be used include birch, beech, mahogany, poplar, gaboon, walnut and oak. Birch is considered to be the best selection when good mechanical properties are desired, and beech for electrical properties. Illustrative of the importance of the wood in deciding mechanical properties of the product can be quoted test results showing a variation in tensile strength from 3 to 23 tons/sq. in. for various qualities of the same type of wood.

Fig. 36 (from "Machinery") shows water absorption values over extended periods for wood, Jabroc and Insul-jabroc. The marked superiority of the Jabroc-densified laminated wood over wood and plywood in this respect is

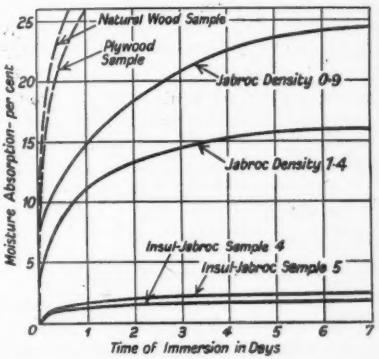


Fig. 36.—Comparative moisture absorption curves.

clearly shown. Again, the relatively non-absorptive nature of Insul-jabroc is also demonstrated.

Jervis states that the most suitable veneers are those generally defined as "clear-straight-rotary-cut," and that thickness is of great importance. Whereas, previously, thicknesses from 0.75 to 1.5 mm. had been used, for Jabroc and Insul-jabroc 0.55 mm. have been found particularly useful for the majority of general applications. These thinner veneers may be more readily dried, and the final product that they yield is a mechanically stronger board than is

obtained when the thicker veneers are utilized.

The types of resin available for this class of work include cresol-formaldehyde, urea-formaldehyde and phenol-formaldehyde in liquid form. The orthodox glues can, of course, also be used, but they have not the water resistance and stability to give the same permanence and high mechanical qualities that are provided by the synthetics.

Apart from the material aspect just presented, there are process and method features from which the best combination has to be determined. The mode of predrying the veneers, the degree of drying, the method of applying and spreading the adhesive, the arrangement of successive laminæ with respect of grain direction: all of these call for a precise decision and control in production. Again, they give the possibility of a range of grades. The predrying should have some relationship to the final resin content of the product and thus to the normal stable moisture content of that product. The liquid resin can be applied by spreading with brush or rolls, or by vacuum impregnation. Grain direction will be determined by the purpose for which the product is intended.

Size Production of Jabroc

Jabroc is produced in sheets or boards 16 ft. square and of various thicknesses, and the great area of these pieces should convey some idea of the magnitude of the problem and of the credit to be accorded to its successful commercial solution. Obviously, veneers of this size are not obtainable. The veneers, after sorting, clamping in bundles and cutting to size, have their edges trued. The edges are brushed with the adhesive and joined edge to edge in jointing machines of ingenious construction. The sheets so procured are stacked with layers of the glue or resin between alternate veeners, and pressed hydraulically, during which the stack is reduced in thickness, a factor which must be taken into careful consideration in order to obtain a board of predetermined thickness. Fig. 37 (from "Machinery") shows this compression feature diagrammatically, pictorially demonstrating the manner in which the resinous adhesive films fuse into the surfaces of the laminations.

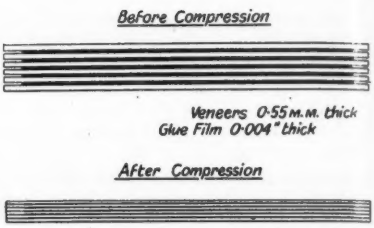


Fig. 37.—Diagrams showing lamination packs before and after compression.

In the pressing operation, hydraulically operated rams are used, and the pressure attained is of the order of 2,000 lb./sq. in., as compared with a matter of hundreds of pounds for plywood. Multi-daylight presses are employed to press several boards at once. The daylights are wide open when loaded and close gradually to the predetermined limit as the pressure is applied. One more platen is used than the number of packs pressed, and the number that can be pressed in a single operation is dependent upon the thickness of the packs concerned and the clearance between the platens.

The temperature of the platens is raised from room temperature to approximately 160 degrees C. as the pressure is applied,

Table 2.—The Properties of Jabroc Compared with those of Different Metals

Weight per cubic ft., lb.	Material	Ultimate tensile strength, lb. per sq. in.	Ultimate compressive strength, lb. per sq. in.	Tensile strength divided by weight
159	Cast aluminium	15,000	12,000	94
449	Cast iron ..	15,000	80,000	33
536	Cast brass ..	24,000	30,000	44
532	Cast gun-metal	32,000	20,000	58
87	Jabroc	34,000	23,000	390
486	Structural steel	60,000	60,000	123

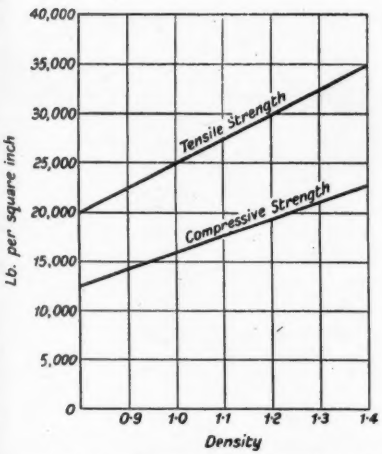


Fig. 38.—Graph showing the tensile and compressive strengths of Jabroc for various densities.

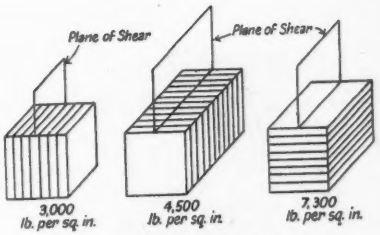


Fig. 39.—Shear strengths for various planes of shear.

lished heating methods, but super high-frequency heating is the promising method for the future. Cold water circulation for the cooling will still be necessary, of course.

Upon removal from the presses the edges of the boards are trimmed, and, for some applications, are sealed by means of varnish. In Table 2 (from "Machinery")

Table 3.—Physical Characteristics of Jabroc Compared with those of Different Woods.

Material	Specific gravity	Weight per cubic ft., lb.	Ultimate tensile strength, lb. per sq. in.	Ultimate compressive strength, lb. per sq. in.	Shear strength at right angles to fibre	Shear strength parallel to fibre
Spruce	0.48	30	9,000	4,500	1,200	800
Beech	0.75	47	18,000	9,000	2,140	1,250
Ash	0.77	48	15,000	7,000	1,200	800
Oak	0.80	50	13,250	5,760	3,890	1,080
Jabroc	1.4	87	*34,000	23,000	7,300	3,000

* 34,000 to 47,000 depending on type and arrangement of veneers.

again contrasting with plywood manufacture in which the load is usually placed between hot plates. As the heat increases, the resinous layer gradually melts and then polymerizes. Finally, the platens are cooled. By gradually heating and cooling, blistering of the work is avoided. The combination of heat and pressure fuses the resinous films between the veneers in the pack to give a dense structure, an actual value of about 1.3 being usual for average work. The individual veneers in the board are reduced in thickness by about 50 per cent., with the thin resin film fused or absorbed into them.

Steam and superheated water circulated through ducts in the platens are the established heating methods, but super high-frequency heating is the promising method for the future. Cold water circulation for the cooling will still be necessary, of course.

Upon removal from the presses the edges of the boards are trimmed, and, for some applications, are sealed by means of varnish. In Table 2 (from "Machinery") are given the properties of Jabroc densified laminated wood in comparison with those of metals. The favourable values for

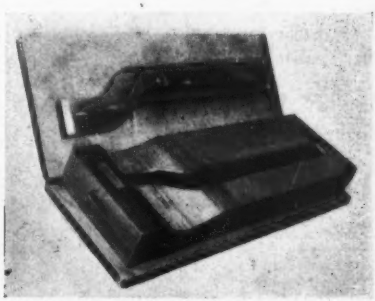


Fig. 40.—Deep drawing press tool.

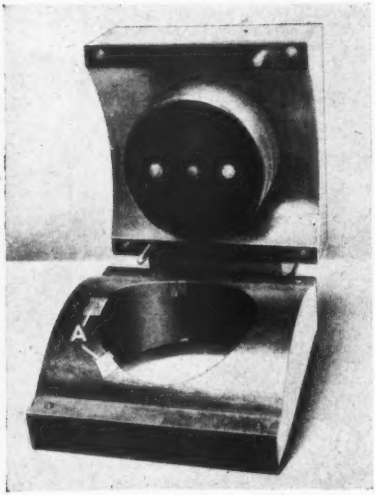


Fig. 41.—Flanging tools made from Jabroc.

Jabroc in relation to its density are to be noted. Fig. 38 gives curves for tensile and compressive strengths for densified woods of various densities, the curves being straight lines, strength increasing with density. Fig. 39 shows the shear strengths, which vary with the various planes of shear. It shows a value of 3,000 lb.-sq. in. in a direction parallel to the plane of the laminations, and of 7,300 lb.-sq. in. when at right angles to them.

Table 3 (from "Machinery") gives the physical characteristics of Jabroc densified laminated wood in comparison with those for a number of woods. The marked mechanical superiority of this versatile material is amply demonstrated.

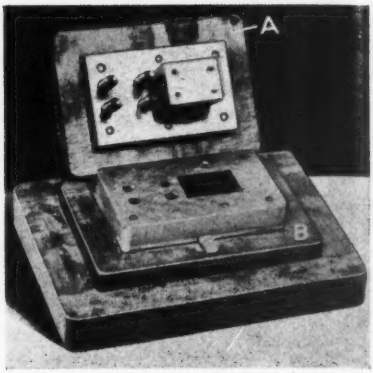


Fig. 43.—A typical set of piercing and blanking tools.

Jabroc is employed for the production of large quantities of jigs, fixtures and press tools for the aircraft and other industries. Lightness, strength and relative ease of working are responsible for this. Lightness is a major attribute when female labour is employed, and makes the

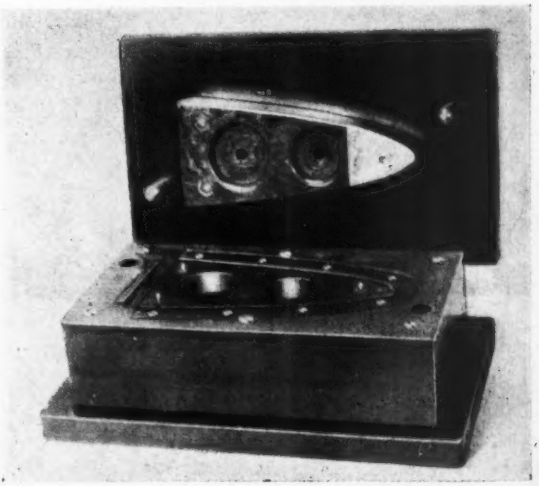
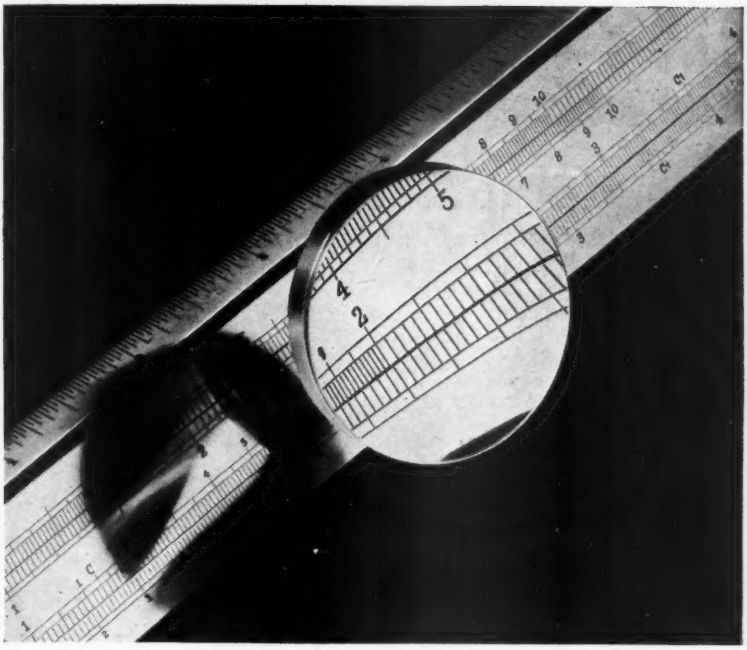


Fig. 42.—Tools for the production of a wing component.



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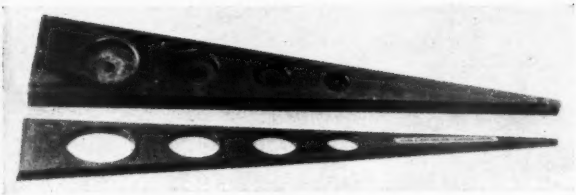

Fig. 44.—A pair of simple flanging tools.

material very suitable for such items as drill jigs and inspection fixtures. Ease of modification to accommodate the frequent engineering changes that occur is another important factor.

Fig. 40 (from "Machinery") shows a typical press tool for a deep drawing operation upon duralumin sheet, made almost completely from Jabroc. The Jabroc flanging tool in Fig. 41 (from "Machinery") includes a number of metal inserts shown at A, situated at points where special wear is likely to be encountered or where buckling of the material might occur. Fig. 42 (from "Machinery") shows a typical press tool for the production of a wing-top component; the working parts of this tool are of Jabroc except for the steel inserts which are provided at the points where wear stresses are concentrated. For blanking tools, bolsters of Jabroc to which the steel tools are fixed, are used. Thus Fig. 43 (from "Machinery") illustrates this, A and B being the Jabroc bolsters which carry the steel blanking and piercing tools. This procedure signifies a substantial economy in steel and an appreciable saving in weight.

Fig. 45.—Typical inspection block for use in an aircraft factory.

Figs. 44 and 45 (from "Machinery") show flanging tools and an inspection jig, respectively, in densified wood. Fig 46 (from "Machinery") illustrates an assembly and inspection jig for an aircraft gun turret component. In this the locating pins and gauging plugs are of steel,

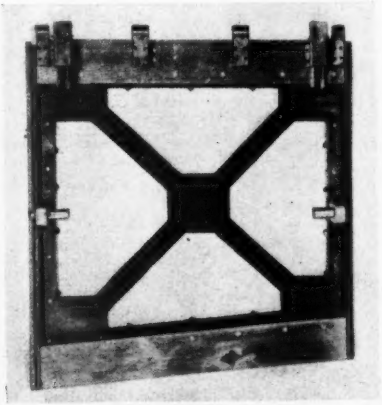

Fig. 46.—Assembly jig and reference gauge for a turret assembly.

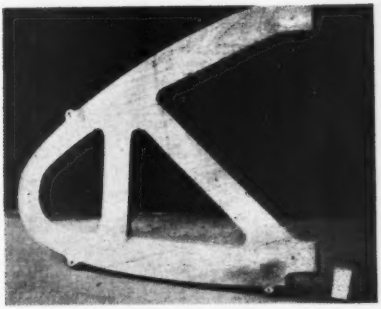

Fig. 47—Routing template for an aircraft nose rib.

Fig. 48.—Large drilling jig.

with the main part of the structure of Jabroc. Fig. 47 (from " Machinery ") is a routing template for an aircraft nose rib. In the case of drill jigs constructed in densified laminated wood, the drill bushes are usually of steel, inserted in holes machined on a jig borer. A large drilling jig is shown in Fig. 48 (from " The Engineer ") and this photograph stresses the advantage of this type of material from the handleability angle.

Fig. 49—Flanging tool.

Fig. 49 (from " The Engineer ") shows a swaging and flanging tool. When extremely high stresses are encountered, the actual cutting edges of these tools can be made faced with steel, but rarely is it necessary to use more than 10 per cent. of the weight of the tool in steel, so that the weight advantage is not unduly sacrificed.

To provide a guide to the behaviour of this class of material under damp conditions, when exposed to oil, and when subjected to heat, extended tests were made upon pieces of ½ in. in thickness board 1½ in. square. The material tested was the Jabroc type and, for comparison, one of the electrical grades of laminated wood of the vacuum impreg-

Table 4.—Effect of Oil Immersion upon Synthetic Resin Densified Wood. Test pieces 1½ ins. sq. by ½ in. thick.

Immersion in hot oil		Material, ½ in. thick	Per cent. decrease in:—			
Temperature	Time		Weight	Length	Width	Thickness
20°C.	1 day	Jabroc type	0.30	0.20	0.05	Negligible
	7 days		0.35	0.20	0.05	Negligible
	30 days		0.44	Negligible	Negligible	0.10
20°C.	1 day	Impregnated type	Negligible	0.05	0.05	0.05
	7 days		Negligible	0.10	0.05	0.05
	30 days		Negligible	0.15	Negligible	0.05
60°C.	1 day	Jabroc type	0.75	Negligible	Negligible	Negligible
	7 days		3.2	0.25	0.30	0.05
	30 days		7.0	0.30	0.10	0.30
60°C.	1 day	Impregnated type	0.30	Negligible	0.10	0.10
	7 days		0.90	0.10	0.10	0.30
	30 days		2.10	0.20	0.15	0.40

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Table 5.—Effect of Water Immersion upon Synthetic Resin Densified Wood. Test Pieces 1½ in. sq. by ½ in. thick.

Immersion in Water at 20°C.	Material, ½ in. thick	Per cent. increase in:—			
		Weight	Length	Width	Thickness
1 day	Jabroc type	4.25	0.05	Negligible	2.5
7 days		15.0	0.18	0.18	14.8
30 days		25.0	0.45	0.42	25.7
1 day	Impregnated type	1.0	0.05	Negligible	0.30
7 days		6.2	0.05	0.05	0.30
30 days		10.0	0.40	0.40	0.40

Table 6.—Effect of Dry Heat upon Synthetic Resin Densified Wood. Test Pieces 1½ in. sq. by ½ in. thick, Heated for Extended Periods.

Day heat period	Material, ½ in. thick	Per cent. loss in weight at:—	
		60° C.	110° C.
1 day	Jabroc type	4.5	9.5
7 days		7.5	10.5
30 days		9.5	11.0
1 day	Impregnated type	1.0	2.75
7 days		2.0	3.75
30 days		2.75	4.0

nated type. Results are tabulated. Those given in Table 4 show the influence of complete submersion in machine oil at the two temperatures of 200 degrees C. (room) and 60 degrees C. Loss in weight and shrinkage universally results. At 20 degrees C. the Jabroc material is not significantly affected, but at 60 degrees C. it loses weight, especially in the full test period of 30 days. This weight loss is, of course, to be expected from a drying-out point of view, but it seems to be compen-

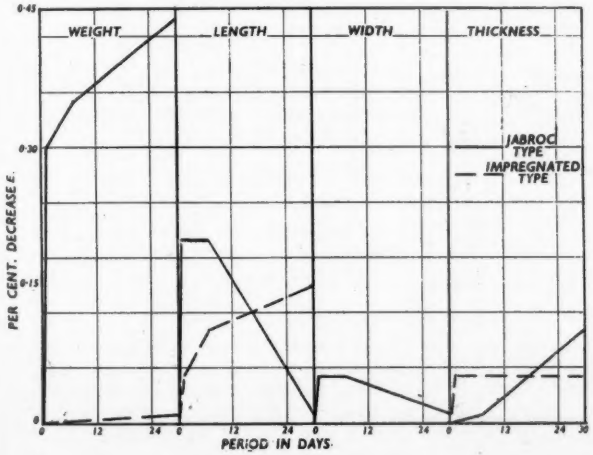

Fig. 50.—Effect of oil immersion on densified laminated wood at 20°C.

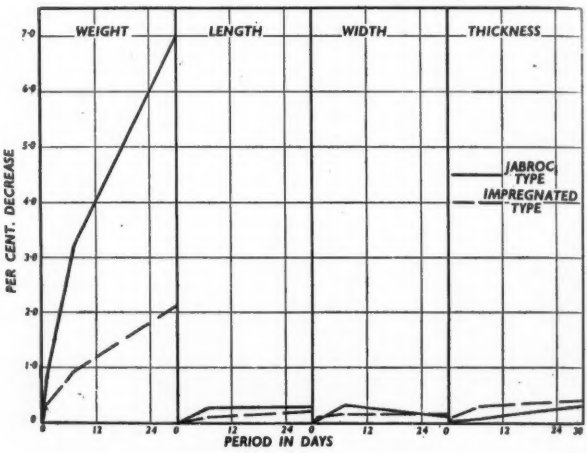

Fig. 51.—Effect of oil immersion on densified wood at 60° C.

sated by at least some oil absorption, because, even in the full period, dimensional shrinkage is not severe. Similar remarks apply to the impregnated grade, except that the total weight loss is appreciably smaller.

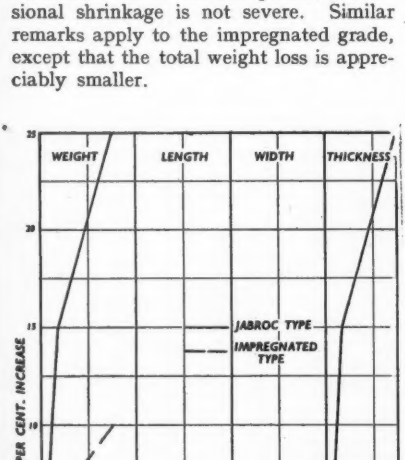

Fig. 52.—Effect of water immersion on densified laminated wood at 20° C.

Increase in Weight of Jabroc, etc., on Water Immersion

Under conditions of water immersion at ordinary temperatures, both materials show a weight increase as well as expansion in all dimensions. This is shown in Table 5. The Jabroc type of material reveals a gradually increasing water absorption to the relatively high figure of 25 per cent. in 30 days. The main movement in dimensions in confined to thickness, especially near edges, the ultimate increase recorded being about 25 per cent. The impregnated type of material shows a much lower total water absorption (about 10 per cent.), and peculiarly no such marked expansion, no increase being greater than 0.5 per cent. in the full period of 30 days.

Loss in Weight on Drying

Weight losses due to " drying out " at 60 degrees C. and at 110 degrees C. are shown in Table 6. The ultimate loss for the Jabroc type of material is of the order of 10 per cent., and for the impregnated type about 4 per cent.

To convey these values more clearly, they have been graphed, viz., Fig. 50 effect of oil at 20 degrees C., Fig. 51 effect of oil at 60 degrees C., Fig. 52 effect of water immersion, Fig. 53 influence of dry

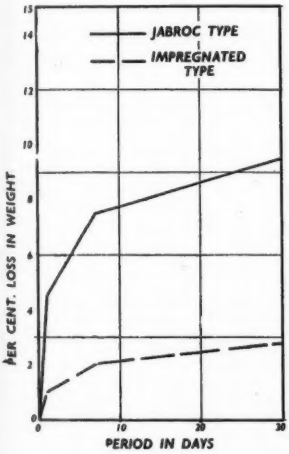

Fig. 53 (left) Effect of dry heat at 60°C. on densified laminated wood.

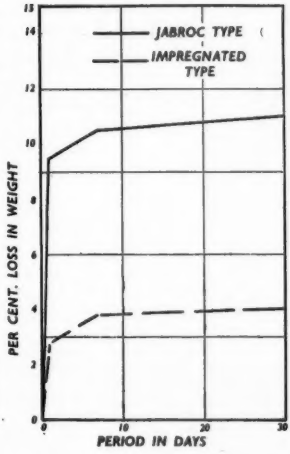

Fig. 54 (right) Effect of dry heat at 110°C. on densified laminated wood.

heat at 60 degrees C. and Fig. 54 influence of dry heat at 110 degrees C. These figures impress the general stability of this material and warn against excessive water contamination. Taken into consideration with the mechanical and physical qualities already discussed, they confirm the availability, in the Jabroc class of densified laminated wood, of a general purposes tool-room material having possibilities of wide applications and an assured future, a material having many advantages when correctly applied to the jobs for which it is suited. There is a large number of such applications.

(To be continued.)

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PRODUCTION NEWS

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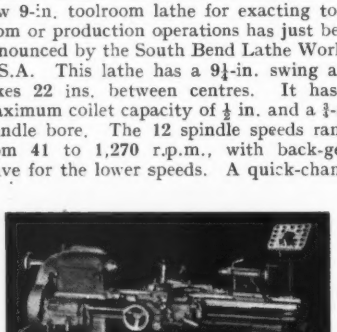
NEW 9-IN. TOOLROOM LATHE.—A new 9-in. toolroom lathe for exacting toolroom or production operations has just been announced by the South Bend Lathe Works, U.S.A. This lathe has a 9¼-in. swing and takes 22 ins. between centres. It has a maximum collet capacity of ½ in. and a ¾-in. spindle bore. The 12 spindle speeds range from 41 to 1,270 r.p.m., with back-gear drive for the lower speeds. A quick-change



gearbox permits cutting 48 pitches of screw threads, 4 to 224 per inch; and provides 48 power longitudinal feeds and power cross-feeds. The lathe is equipped with a hand-wheel draw-in collet attachment, collet rack, taper attachment, thread dial indicator, thread cutting stop, large and small face plates, and micrometer carriage stop. Additional attachments are available which simplify the machining of special classes of work.

Complete information on this lathe can be obtained by writing to the South Bend Lathe Works, 263, E. Madison Street, South Bend 22, Indiana, U.S.A.

THE GAUGE AND TOOL MAKERS' ASSOCIATION.—The export committee of the Association has met regularly since its appointment and has done valuable work, for example, interviews have been made with many Empire, Dominion and foreign Governments to ascertain post-war requirements of British tools and gauges.

The committee has given considerable thought to the possibility of sending British tools and gauges overseas by air and discussions are in progress with the British Overseas Airways Corporation. The B.O.A.C. is aiming at a post-war freight charge of 3d. or 6d. per lb. weight per thousand miles, and it would appear that the products represented by the Association are eminently suitable for air transport.

SCOTTISH PLASTICS, LTD.—Mr. B. C. Westall has relinquished the chairmanship of Scottish Plastics, Ltd., owing to pressure of other duties. He retains his seat on the board.

Mr. C. G. R. Ashton has been appointed to succeed him as chairman of the company.

SOCIETY OF CHEMICAL INDUSTRY (PLASTICS GROUP).—The third meeting of the 1944-45 session will be held on Friday, December 15, 1944, at 2.30 p.m., in the rooms of the Chemical Society, Burlington House, Piccadilly, W.1. A paper entitled "Kinetics of Vinyl Polymerizations in the Liquid Phase" will be read by Dr. R. R. Smith, of the Research Department, The Distillers Co., Epsom.

INSTITUTE OF THE PLASTICS INDUSTRY (MIDLANDS SECTION) sends us the following information:—On Friday, December 15, 1944, there will be a lecture meeting commencing 6.30 p.m. at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3, when a paper will be read by A. A. Heath, Esq., M.A., A.M.I.E.E. (New Insulation Co., Ltd.), entitled "Densified Wood Laminates." Refreshment served from 5.30 p.m.

On Monday, January 8, 1945, a luncheon meeting will be held at The Crown and Cushion Hotel, Perry Barr, Birmingham, 20, commencing 12.30 p.m., lunch at 1 p.m. Arrangements are being made for an officer of the United States Forces stationed in this country to give a talk, the anticipated title being "Plastics in the U.S.A." Application for tickets should be made direct to the hon. secretary, C. P. Hughes, Esq., care of Bakelite, Ltd., 1, Kineton Green Road, Olton, Birmingham 27, immediately.

Planned Mould Maintenance Service Aids Economical Production

Part VIII

By W. M. HALLIDAY

Injection moulds intended for the production of threaded components especially should be designed on sound lines, and also maintained in the best working condition so as to avoid errors, faults and inaccuracies in the finished moulding.

In this issue special consideration is given to some conventional designs and methods of construction to note unsatisfactory features.

Improved design and constructional forms are also here suggested which are calculated to reduce maintenance service to a minimum.

IN this present section attention is directed to a very important class of injection moulds, viz., those designed for the formation of either internally or externally threaded moulded articles.

Having to produce a threaded portion on a plastic moulded component very often involves special design and constructional considerations, which result in the incorporation in the mould of features to maintain either very close accuracy or uniformity. Because of such stringent demands, very often the mould construction becomes complicated, or possesses a high degree of accuracy. Precision and smooth operation of such a mould require very careful maintenance attention throughout the production run.

As is well known, in the moulding of a plastic part considerable time and labour may be saved on subsequent machining operations if screw threads are moulded upon the component simultaneously with the formation of the piece in the mould, rather than by cutting such threads at a later stage to moulding.

Such moulded threads, if carefully reproduced from an accurate mould, require no subsequent machining operations save that of a die-chasing one to remove either the parting-line flash, or a fine shaving in order to bring the threads to the correct size of pitch and diameter.

In numerous mould constructions for forming threads, notably those which employ detachable cores which have to be ejected from the mould with the finished moulding, and then unscrewed by a separate manual operation, the production cycle tends to become very appreciably increased. Furthermore, the correct location, alignment, and continued close degree of fit between such withdrawable core pieces and their housings in the mould block, etc., are each of some importance, their satisfactory solution presenting many problems for the maintenance toolmaker.

In the case of a multi-impression tool for moulding simultaneously a number of threaded articles, the various methods adopted for securing the rotation of all cores in proper unison and timing are often complex. Thus, for example, on some types of moulds it is possible to employ one or more operating racks meshing with pinions attached to the ends of the threaded cores, the whole mechanism then being actuated either by the opening movement imparted to the mould blocks or by a separate manual or mechanical means external to the mould blocks and independent of their motion. The purpose of such mechanical arrangements is to secure simultaneous operation of all cores during the unscrewing from the finished moulding; which, by the way, is then performed within the mould block itself before the finished part is ejected; and the proper return of the empty cores in readiness for the next moulding cycle.

As will be appreciated all such mechanisms where possible in a mould construction offer innumerable avenues for the display of the designer's skill and ingenuity, but it must also be remembered that they will usually entail addi-

tional demands upon the attentions of the engineer charged with mould maintenance, whose task is often rendered more exacting by this introduction of complicated core rotating mechanisms.

The foregoing are some of the features, along with a number of others, which it is proposed to consider in the ensuing notes.

Method of Presentation

The method to be followed is similar to that adopted throughout the preceding sections. First, as a preliminary step, some attention will be given to the various errors likely to arise in connection with moulds for making threaded components, then various types of mould designs and constructions for producing externally threaded components will be dealt with, to be followed by a similar treatment of mould designs for fashioning internal threads. In each case a number of illustrations will be appended to show commonly used design forms and to stress disadvantageous features. Likewise, other illustrations will then be shown to indicate possible lines of improving such designs to overcome difficulties, etc.

Errors in Threaded Moulded Parts

A number of errors due to misalignment of mould blocks, misplacement of cores, or some other cause, result in the creation of certain faults in the finished part. These are usually more serious in the case of the threaded component than with a plain one. The seriousness arises from the difficulties which have to be overcome when having to correct a threaded moulded article. It is often quite impracticable to effect such correction without producing a drastic departure from essential thread form or size. For example, if a sizing die (of the button type) is employed, passing this along the inaccurate threads may cause too much material to be removed either from thread flanks, or root, or crests, which, in turn, will make for a too poor a fit between the mating internally threaded part.

At Fig. 1 is illustrated a very common form of thread part error. The component is a head stud whose shank is moulded in three different diameters, the larger of which is externally threaded. This part is produced in a split-type mould, and, as will be seen, the parting line runs longitudinally and parallel with the lengthwise axis of the piece.

The error to be noted consists of the lengthwise misplacement of the two halves of moulding (each formed in one of the mould blocks) due to the misalignment of these latter when in closed (injecting) position. As will be seen at the parting-line juncture, the threads do not correctly match up. If a ring gauge be passed on to such a thread it will jam tight, thus giving the false impression of an oversize thread, or on the other hand, if the diameter of the thread is slightly below the low limit, the gauge may show an axial deflection.

If a sizing cutting die is passed on to this kind of thread to attempt to correct it, material will be removed at opposite flanks of the thread as shown at *a* and *b*, respectively. If this is done, the

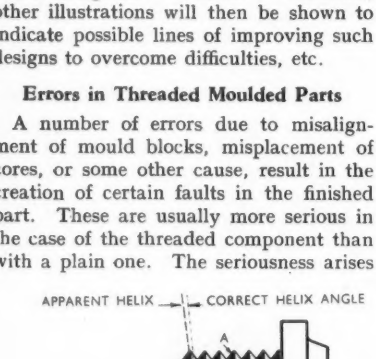


Fig. 1.

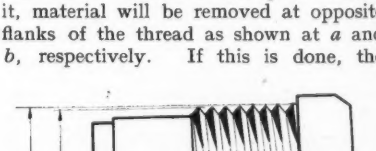


Fig. 2.

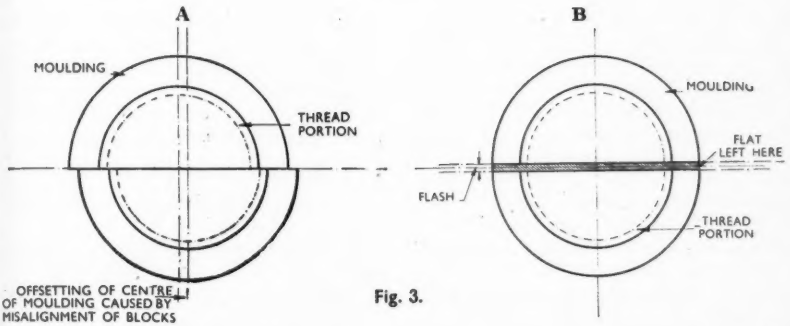


Fig. 3.

thread shape will be incorrect, although such action will enable the ring gauge or mating member to be screwed on without tightness.

Where the amount of such endwise displacement is considerable, or where fine pitch threads are concerned, passing the cutting die over threads in above manner will result in a considerable reduction in flank thickness and height, and consequent serious departure from accuracy.

The next kind of error commonly encountered on threaded articles is the failure to produce exactly parallel threaded portions. In the split-type mould this generally arises because of a slight opening of the mould blocks at one side when the material is being injected into the cavity. This results in the formation of a thick flash along the longitudinal parting-line junction as shown in Fig. 2, whilst the thread diameters are likewise increased. If a sizing cutting die is passed down such a tapered thread, difficulties arise in removing the thick flash, and in obtaining a truly circular thread. The material to be removed from the larger diameter, as at Y, in order to bring the threaded portion parallel and to correct diameter X may in some cases be so much as will produce an undue thinning of the thread flanks on the sides adjacent to the parting-line.

The two end views shown at A and B in Fig. 3 illustrate other errors commonly arising in the shape of ovality of threaded portions. This latter feature generally is traceable to faulty mould block alignment because of bent or slack dowels, etc., or the imperfect closure of the blocks.

The left-hand view at A shows a shouldered moulding which possesses an effect of ovality produced by the failure of the mould blocks to register correctly diametrically. Each half portion of the moulding will, of course, be truly semi-circular. If a sizing cutting die is passed over such malformed thread, material will have to be removed from the left-hand overhanging side of the upper portion and from the opposed overhanging right-hand side of the lower portion. If the amount of overhang is excessive a very badly shaped thread may result from passing the cutting die over it. Passable threads may be obtained if the overhang is only slight, but gaps will be shown with the thread gauge.

An oval moulding may also be made in those cases where the mould blocks are not properly closing over their whole area. In such instances the finished moulding will be marred by the presence of a thick flash along the parting-line juncture in addition to ovality. The exterior edge of this flash will not lie truly radial, resulting in the presence of a slight flattened portion at each side after it has been removed by the passage of the sizing die. This undesirable feature is clearly indicated in illustration B at right-hand side of Fig. 3.

Several causes may produce such ovalness. There may be an adequate amount of locking pressure on mould

blocks when these are in the closed position in readiness for an injection "shot." If this should occur the blocks may be forced slightly apart by the pressure of the incoming plastic material. Again, the mould blocks may be prevented from completely closing, due to the presence of small particles of dirt of lodging material left over from previous "shots." Yet, again, bent, loose or scored dowels may allow mould block opening. Sometimes a slightly misplaced core member may be found preventing the proper closure of the blocks.

Detection of any such factor will, of course, be one of the main aims of the observant maintenance engineer, and in the case of moulds for threaded components, inspections, and tests for such minor snags should be very frequently made. More on this aspect will be mentioned at a later stage.

Ovalness may assume serious proportions in those cases where the moulding is provided with a centrally located internally cored hole. If there is any mould block opening during injection not only will the finished part be distinguished by heavy flash around parting-line edge, but there will be a certain lack of concentricity in respect of the positioning of the hole. This is bound to arise, because it is usual constructional practice to house such a core member entirely within one mould block, so that any inadvertent moving of the mating block will not be neutralized by a corresponding moving over of the core.

Yet another admittedly minor difficulty often associated with thread moulding deserves attention at this point. It relates to the forming of correct threads right up to a shoulder or step on the part. Where it is essential for this some means will have to be provided on the mould, so that an undercut portion is moulded on the shoulder concerned into which the thread may effectively run out.

In stipulating such provisions, the originator of a moulding design should always carefully consider whether a full thread form right up to the shoulder is really necessary, as this may entail considerable mould constructional problems, or awkward machining operations. Similarly, the mould designer should devote great care to all such provisions lest a too-expensive or difficult undercut forming provision is stipulated.

Moulding External Threads

It is advisable first to consider the various mould designs and their advantages or drawbacks which are in common usage for moulding externally threaded articles. Five such types of mould design will be here discussed, these being typical representations of current practice. These types are as follow:—

1. The split-thread.
2. The mould block cavity.
3. The threaded insert.
4. The lateral slide.
5. The interposed plate cavity.

These will be considered in the above order.

The Split-thread Type of Mould

This type of mould is based on the principle of so arranging the location and disposition of the threaded cavity within the two mould blocks that the longitudinal centre line of the finished piece lies along the parting line of the blocks themselves. This point will be clearly understood by referring to the sectioned drawing shown in Fig. 4.

In this instance the moulded article comprises a cylindrical-headed stud with a large-diameter threaded shank, the remaining plain portions of which are made to various different diameters as indicated.

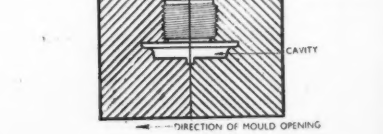


Fig. 4.

Each main mould block houses half the cavity, except for a slight portion which is contained in the sealing plates securely fixed into suitable recesses machined in top edge of each block. The chief purpose of these sealing plates is to allow for machining the cavity and the cutting of the threaded portions therein by simple lathe boring operation. The bulk of the cavity is thus machined in this way before the top sealing plates are placed in position, thereby permitting a sufficiently wide opening for passing in the necessary boring tools, which would not be possible, of course, if two mould blocks alone were used.

One important point to be observed in connection with this design is in respect of the fitment of these sealing plates. Unless a very close fit is made between their bottom faces and that of the step machined in mould blocks, slight gaps may be left into which material will be squeezed during each injection, leading in turn to flash formation, and increased difficulty in ejecting the finished piece.

Such sealing plates need to be very substantially secured by means of ample screws and cross dowels, and the maintenance engineer should, of course, make regular tests of all such fittings to ensure continued tightness of lock and freedom from burrs, etc.

Another important consideration to be borne in mind with this type of construction concerns the machining of the thread direct into the mould blocks. This, obviously, must be performed with great care and precision, and due sizing allowance must be made for hardening and final polishing. There should be ample thickness of stock immediately behind the threaded cavity walls in order to arrest as far as possible any tendency towards distortion likely to arise after hardening.

There will be some wear on the threaded portion of the mould cavity after a time, and usually this is first observed by an enlarging of the root diameter of the threads on the moulded component. The threads on the mould will lose their clear-cut sharpness at the parting-line surface of each block. Correction might mean a relapping of the parting-line faces of the two blocks to remove a small amount of material and also to restore the sharp and full shape condition of the threads at this point.

Several other very desirable essentials will also be needed if such a mould design is to operate smoothly, with accuracy and relative freedom from faults and breakdown.

There should be very ample provision for ensuring the continued accurate registration of the two mould blocks with each other. This may take the form of a number of additional dowels, or their more judicious location, or larger diameter. On the other hand, in the case of large moulds it might prove advisable to instal auxiliary aligning plates on the exterior of the mould blocks themselves. This is illustrated in Fig. 12 (see January, 1945, issue), and will be described in more detail later as the method is applicable to all types of moulds being considered.

Next, some means must also be provided to prevent the slightest amount of opening of the main mould blocks as previously mentioned. This will be generally needed to supplement the locking pressure obtainable from the machine. In the machne members, such as tie rods, platens, toggle joints, etc., there is a certain amount of " spring " which is likely to result in a slight reduction in the locking pressure sufficient to allow mould block opening. Wherever possible some additional positive lock should be arranged on the mould blocks themselves, say, in the form of a hinged claw-shaped lever which is pivoted to one mould block and will drop down and engage over the other block only when this latter member is in the proper closed position. Such an augmenting of the ordinary machine clamping pressure will be found extremely useful, and moreover will furnish some guidance to the operator for indicating in a clear fashion whether there is some obstruction present to prevent the mould blocks from closing properly. The writer has found such a

simple provision as this to work extremely satisfactory and to obviate a number of minor troubles of flash formation, etc., previously arising from slight opening of the mould blocks.

Another much-used design of split-thread-type mould is illustrated at Fig. 5, which shows a sectioned view of the tool for forming a threaded cap plug. It will be seen that the theads are located upon the middle portion of the component. Unlike the method employed in the mould design just described, and illustrated at Fig. 4, it should be observed that the threaded portion of the cavity is embraced entirely within special rectangular strips secured within the main mould blocks as shown.

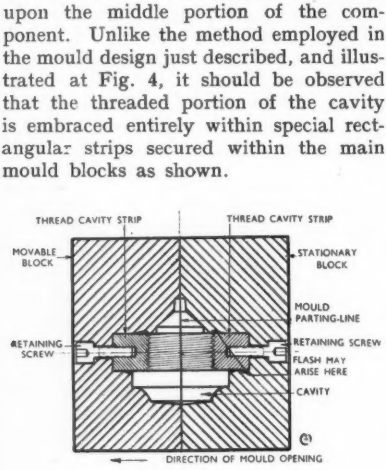


Fig. 5.

Each mould block is recessed from the parting-line face, and in each recess a strip is let in to fit smartly, and of course so located that both strips will match up exactly when the mould blocks are closed. The strips are further retained by means of screws passing in from the outside end-faces of each block; the tapped holes in each strip do not break through into the threaded cavity.

One great advantage of this method of construction is that it permits the threaded portion of the cavity being machined separately and, of course, with greater facility. The blank strips are first assembled very accurately into their respective blocks, and the cavity then turned in the composite blocks. The strips are then removed and conveniently clamped together, and set up in the lathe for threading the bored hole previously formed in them. The parting-line of the two strips must exactly coincide with the centre line of the bored hole, and in addition the width of the strips should be made precisely that of the length of thread desired.

Apart from greatly facilitating machining, and especially the forming of the thread, use of strips in this fashion also very greatly simplifies the task of renewing worn threaded portions of the mould. Where an excessive amount of wear has occurred, the mould maintenance engineer will simply remove the strips containing worn thread cavity, fit in new ones, and follow the same machining procedure as undertaken in original stages of their manufacture. Thus a completely new and accurate threaded cavity can inexpensively and very quickly be secured.

Yet another useful feature to be observed in connection with this type of mould is that it enables the toolmaker to incorporate unusually shaped threads, or ones of very small root diameter, which otherwise might prove entirely impracticable where such machining has to be performed directly in the main mould blocks.

Certain drawbacks are present in this construction, however.

The first refers to the method of fitting the strips into the main blocks. Unless the recesses machined in these latter are extremely accurate as regards width, parallelism and flatness of sides, it may be found that slight gaps are present when the strips have been fitted. Should this occur risk of undesirable flash formation may be incurred. Such flash will usually be located at the points indicated in the drawing.

In addition such a flash may also cause ejection difficulties when the moulds are opened, as it will have to be pulled out of the small opening when moulding is withdrawn.

Next there is a likelihood that such strips may work loose after a period of working due to the retaining screws in the block becoming slightly eased off.

This latter may arise from several causes, such as a stretching of the threaded shank of these retaining screws, slacking off by vibration, etc.

Unless the thread cavity strips are made of very stiff cross-section there may be a danger of distortion taking place because of temperature variations, or from the effects of the elevated pressures resultant from clamping to which the strips will be subjected during their working life. Should such warpage develop it may be found that some portions of these strips on their parting-line surface are actually projecting beyond the similar face of the main blocks.

This will not only result in the finished moulding having a much thicker flash than normal or permissible, but will also open up the liability of it being moulded with either a tapered or oval-shaped threaded portion.

It will also be well appreciated that it is equally important for both main blocks to be well dowelled so as to preclude all possibility of their misalignment. In actual practice all those preferable features already mentioned and discussed in reference to the previous mould design exhibited in Fig. 4 will apply in this present instance with the same degree of importance.

The maintenance supervision demanded by this type of split-thread mould construction will largely centre around the question of accurately registering the two blocks together; ensuring a perfect sealing of same on their parting-line surfaces; testing the thread cavity strips at very frequent intervals throughout every production run for security of fastening; absence of distortion; or any developing openings between sides of strip and the recesses in blocks in which they are fitted.

If regular inspections are made of the foregoing points, preferably once every three or four hours during production, very little serious trouble should arise, whilst numerous minor faults will be detected in their earliest developing stages and speedily corrected. Thus production should be smooth and uninterrupted, whilst the finished articles will be better maintained to initial levels of accuracy and finish.

The design of split-thread mould shown in Fig. 6 is one that possesses a number of very unsatisfactory features which are likely to entail the mould maintenance toolmaker in some trouble. As will be noticed the thread cavity in this case is also entirely contained within a pair of separate strips, these latter being interposed between the top and bottom portions of each main mould block, these members being made up of two portions each, as indicated.

Special binding studs are used to secure the thread cavity strips correctly in position between their respective main block members, the studs being threaded

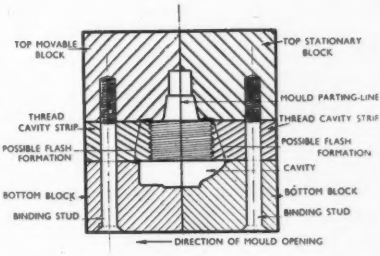


Fig. 6.

into tapped holes in the top blocks as shown, and then riveted well over on the lower edge of each bottom tool.

As in the previous design already dealt with considerable convenience for machining the threaded cavity form is possessed by this construction, as it is quite possible to finish this portion completely prior to the final assembly of the strips between the mould block sections.

The working disadvantages, however, will be found to outweigh such manufacturing benefits, as will be appreciated from the brief listing here made of such drawbacks to smooth and prolonged operation.

(a) In the first place, it is exceedingly difficult to maintain a sound and material tight seal between the various surfaces of the thread cavity strips and the mould block pieces, especially when the mould

is subjected to fairly continuous use. Such a mould construction, if used on any appreciable scale, will speedily show signs of slight openings between the respective pieces. These will then become interstices into which plastic material, particles of dirt or oil may find lodgment. With a slight opening or shift between the various composing plates, etc., of the mould blocks occurring, the way is then opened for ejection troubles, as the slight flash caused will have to be pulled out of the gaps before the finished moulding can be freed.

(b) Should a loosening of the thread cavity strips occur, as is likely when the mould is placed under heavy pressure, then the threaded portion of the finished

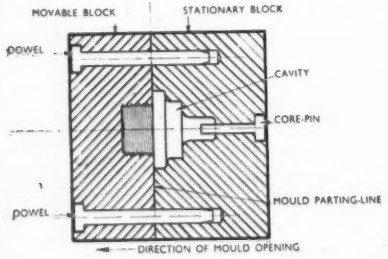


Fig. 7.

moulding will lie off the correct centre with the rest of the piece.

(c) When the two-mould blocks are clamped together in readiness for an injection operation, some considerable shearing stress will be imposed upon the binding studs retaining the various mould parts in position. Should these studs suffer any bending strain the separate parts of each mould block may become misaligned, which, in its turn, will affect the parting-line surface sealing fit.

(d) Damage is also apt to be caused to such a mould whilst it is being handled, as when removing from the injection machine, or placing into a storage bin, etc. Any severe drop or contact with another object may produce a misalignment of the various parts of each mould block.

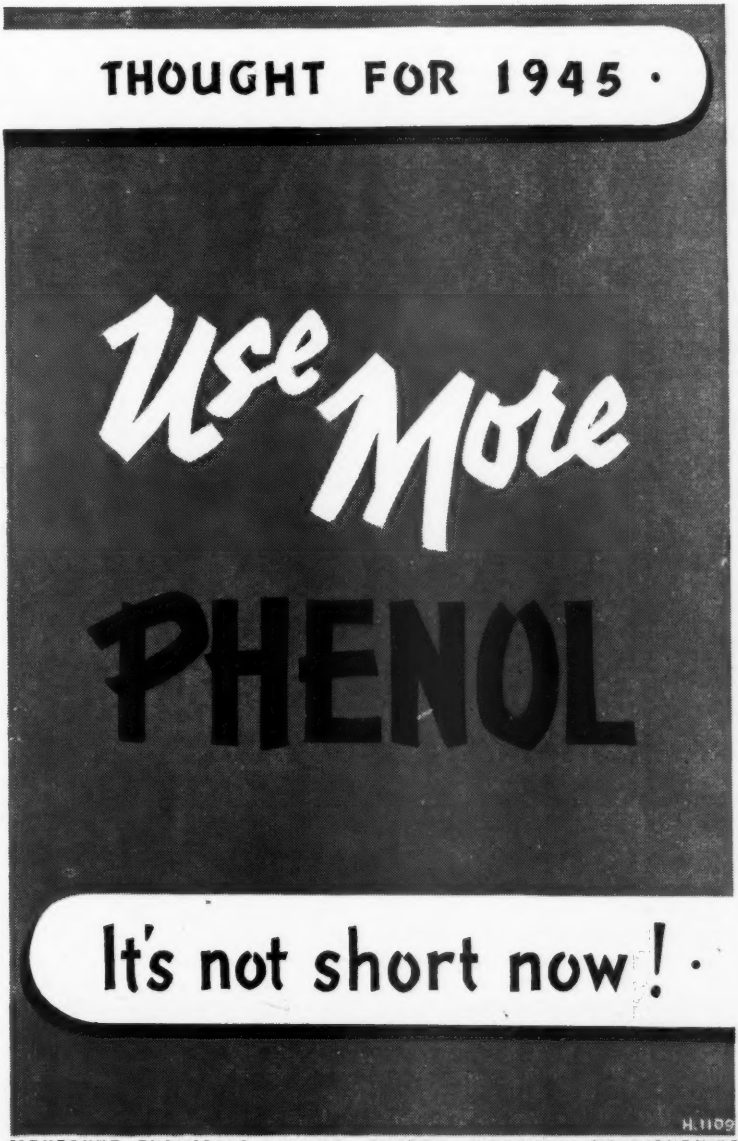
Because, then, of these four disadvantages alone, the maintenance engineer will have to devote extra care and attention if serious mould failures or component faults are to be avoided, and such a design can only be recommended for producing an exceedingly small quantity of articles the cost of which would not bear a high tool charge.

Additional strength and rigidity could be afforded to the mould block construction if a very stiff steel plate were to be attached to the back vertical face of each composite block. This plate would have to be of the same overall dimensions as the blocks, and secured thereto by means of screws, a number of these latter being located in both top and bottom blocks as well as in the rear of thread cavity strips. But such a procedure would be almost equivalent in machining time to that required to sink the cavity strips into machined grooves in the parting-line surface of each mould block, as in the previous design illustrated in Fig. 5. And employment of such an expedient would also incur extra inspection and test requirements to be watched for and attended to by the maintenance toolmaker, who would have to check the steel back plates for absence of distortion, firm fixture, and so on.

The Mould Block Cavity Type of Construction

Turning now to another very extensively used method of injection threaded-mould construction, which is illustrated by a sectioned view shown at Fig. 7, it will be noted that the threaded portion of the cavity is contained entirely within the movable mould block. In this case, however, the longitudinal axis of the threaded portion of cavity is located at right angles to the parting line of the two blocks as indicated. Thus there is no flash caused along the sides of the finished thread portions of the moulding as in the case of the split-thread mould type.

This form of thread moulding, however, requires that the finished part must be *unscrewed* from the cavity in the movable block after each injection. This



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may be performed manually or by automatic means, which requirements entail some slowing down of the output rate. Usually in the case of multi-impression moulds some simple automatic method of unscrewing the finished articles is adopted in order to reduce unloading time. Small mouldings may often be speedily extracted by means of a power-driven screwdriver, or electric drilling machine of a power-driven type. Such appliances may have to be fitted with suitable contact provisions to engage plain portions of the moulded article so as to obtain a grip upon the same sufficient for unscrewing purposes.

With this construction it is again imperative that each mould block registers very accurately with the mating member, and that the slightest wear in dowels or their guide holes shall be detected and given corrective attention.

Another snag which may arise relates to the run out of the thread at both the parting-line surface of mould block and also at the base of the cavity. As will be understood, ordinary tooling methods generally adopted for performing such mould cavity machining will produce a feather edge at the thread run-out. Such a fine edge is liable to distortion, or breakage by reason of hardening of the mould, or too careless extraction of a finished moulding, or lack of care in handling the mould block. If this feather-like run-out is damaged it will cause a thickening of the thread form on the plastic product. The maintenance toolmaker would therefore pay especial attention to this feature when making his regular inspections of the mould in order to discover early signs of possible chipping or wearing away of this feather edge. Should this snag arise on the parting-line surface, correction would be a simple matter, provided no strict length tolerance was imposed. It would then simply consist of removing a slight amount of material from the parting-line surface of the mould block concerned until the fine, unbroken feather edge run-out of thread had been restored.

Yet another point needing close attention in respect of this type of mould is in preventing any opening of the blocks during injection. Not only will this produce an additional flash at the junction of the threaded portion with the rest of the moulding body, but it will also mean that the threads will not be continued right up to the shoulder of the moulding as required, and this blank portion may be too short to correct by passing a sizing die down the thread.

It will be observed that this type of construction is really only applicable in cases where the finished moulding is to be threaded right out at one end, or where its largest diametered portion is to be threaded. It would not be possible to remove a finished moulding from the threaded cavity in the movable block if it had to have a larger diameter beyond the left-hand end of the threaded portion.

One very useful service to be performed by the maintenance engineer in respect of this type of mould would be to undertake a careful training of the operator having to use it so as to ensure he is appraised of the need for care when cleaning the parting-line surfaces of blocks, and removing the finished part. The writer has often encountered instances of damaged cavity entrances due to the operator inadvertently striking the threads with a metallic article used for scraping off surplus oil or plastic material usually adhering to the surface. Similarly, when removing the finished moulding, care should be exercised lest it be jammed on the last two or three threads, an action which is liable not only to damage the plastic moulding but also to cause a chipping of the threads of mould cavity. In using this type of mould it is essential that it be handled, stored, and operated with care and understanding.

If space permitted, examples could be given illustrating various simple devices which could be employed in order to assist in avoiding such troubles, but no doubt the far-seeing maintenance engineer will be able to devise and install effective measures to facilitate manual unscrewing of the finished product.

The Threaded-insert Injection Mould

A very simple yet effective design of injection thread-forming mould is shown

at Fig. 8. This type is usually employed where the threaded portions of the article are of larger diameter, or where unscrewing difficulties would be too great for the use of a construction similar to that described in Fig. 7.

Examination of the constructional features shown in this sectioned illustration will indicate the principle employed. The threaded cavity is contained within a separate disc-like insertion piece, which, in its turn, is let into a suitable recess within the parting-line surface of the movable block. This insert should be a snug push-in fit within its recess, and an ejector hole should be machined from the left-hand face of the mould block into that of the insert recess. Down such a hole a rod may be passed for pushing out

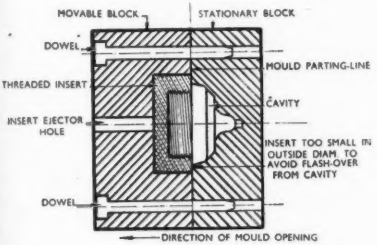

Fig. 8.

the insert after the injection has taken place and when the mould blocks are brought to their open position. The insert is machined exactly in line with the parting-line surface of the mould block.

The operation of such a mould would then be as follows:—An empty insertion piece would first be placed into the recess in the movable block, then the latter member would be closed against the stationary block. After injection, the mould block would be withdrawn, and the loaded insertion disc ejected, either automatically by reason of a fixed rod passing up the ejector hole against which the rear face of the insert would contact as the movable block continued its opening, or a loose rod may be inserted within the ejector rod and a blow applied to it to effect the removal of the insert. The finished moulding would then be unscrewed from the insert. Time would, of course, be saved if a number of spare insertion discs were made available so that another operator could perform these unscrewing movements, whilst the machine operator could confine his efforts to moulding proper.

It is advisable to point out a number of practical objections likely to be associated with this design here illustrated. These are:—

The outside diameter of the insertion disc should be large enough to bring the intersection line well clear of the cavity in the mould blocks. If such intersection is located too near the edge of the cavity a flash over of material may result.

No provision has been made for locating the insertion piece in the same place after each ejection.

If the thickness of the base wall at the bottom of the threaded cavity in the insert is too thin, there may be a danger of damaging this by distortion, or bruises, which, in time, will affect the degree of fit of this member. Should slight buckling occur on the insert base it may be caused to overhang the parting-line surface of the mould blocks, thereby preventing their proper closure and sealing.

Yet another very probable source of trouble will arise in respect of the wear which will take place between the periphery of the threaded insertion piece and the sides of the recess in the movable block. Entry of the insert may also take a considerable time due to jamming, or cross locking, as the part is being admitted. Such actions also tend to increase wear by making the hole or recess in the block bell-mouthed.

The dowels or other means of aligning the main mould blocks should be ample and very strong.

An improved design of this type of construction is illustrated in the sectioned view at Fig. 9. As will be noted, the threaded cavity insertion for coring the external thread portion of the finished article is made of ample outside diameter on its larger end, which contains the

cavity. This extends the intersecting line well beyond the edges of the mould cavity.

The reduced cylindrical shank of this member is made a free sliding fit within the plain bored hole passing concentrically from base of recess in the mould block to its left-hand endface, as shown. This hole is also provided with a keyway into which slide the fixed feather attached to the shank of the insert. This provision ensures that the latter member is always located in the same position in the mould block.

The extreme left-hand portion of the shank extends well beyond the endface of the movable block and is slightly reduced in diameter. This forms a convenient knock-out head for ejection of the coring insert. This knock-out head may either be hit manually or caused automatically to bear against a stationary block fixed to the machine frame when the movable block has traversed a predetermined distance throughout its opening movement.

In order to eliminate possibilities of wear between the sides of the insert and its recess in the mould block, a specially hardened sleeve is employed. This is made a tight fit within the recess, and the insert is then made to pass smartly within its bore. This sleeve is readily renewable should wear or damage necessitate such action. Three ejector holes are provided in the movable block whereby a rod may be passed down to force out a worn sleeve prior to replacement.

The practical advantages of this design as far as maintenance service is concerned, will, no doubt, be obvious. First, the insert itself is a very substantial piece in comparison to that employed in the previously discussed design, thereby being liable to far less damage due to indifferent handling during insertion or removal from the block.

Secondly, the presence of the reduced plain and keyed shank renders insertion of the coring-insert much easier and is likely to be attended with much less trouble and risk of damage.

Thirdly, it will be observed that the base face of the recess in the movable block is provided with a shallow undercut portion so as to leave two annular ring portions upon which the bottom of the insert shoulder must bear. Reduction in the extent of these surfaces in contact similarly reduces the likelihood of any adhering material, or dirt, etc., finding permanent lodgment and causing a displacement of the insert in its recess. The writer has found this a most useful measure, as any excess lubricant or small particles of material appear to find their way into this undercut.

With this construction, the maintenance service will comprise checking frequently for alignment of blocks, and the straightness of dowels or other registration

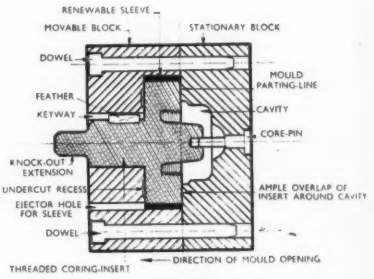

Fig. 9.

means. The insertion piece will also require regular inspection to ensure it is being correctly seated within its recess, and that undue wear is not occurring between the renewable sleeve and exterior of the insert shouldered end. Examination will have to be made for detecting signs of thread chipping or wear of the cavity itself. If desired, the reduced end of the shank of the insert piece could be made hexagonal in shape so that the withdrawn insert may be held in a vice or other gripping tool whilst the finished moulding is being unscrewed therefrom.

Altogether this design will be found to give much more dependable service and sounder mouldings than that previously described.

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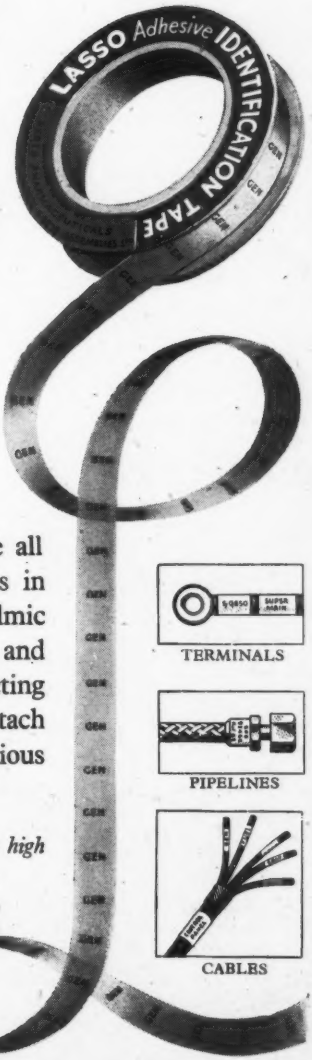

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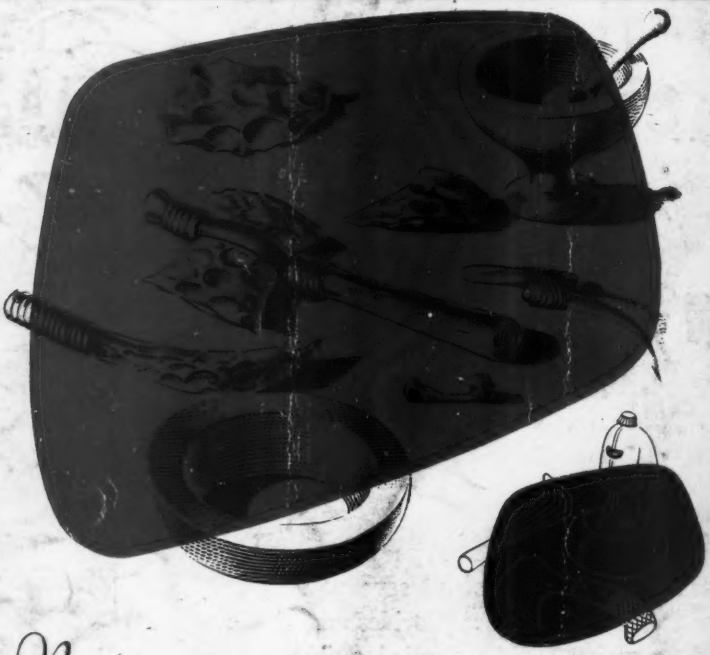

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